AFRL-RZ-WP-TR-2011-2084

PROPULSION AND POWER RAPID RESPONSE RESEARCH AND DEVELOPMENT (R&D) SUPPORT

Delivery Order 0011: Analysis of Synthetic Aviation Fuels

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Southwest Research Institute (SwRI®)

APRIL 2011
Interim Report

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1. REPORT DATE *(DD-MM-YY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
April 2011	Interim	10 August 2008 – 09 November 2010

4. TITLE AND SUBTITLE
PROPULSION AND POWER RAPID RESPONSE RESEARCH AND DEVELOPMENT (R&D) SUPPORT
Delivery Order 0011: Analysis of Synthetic Aviation Fuels

5a. CONTRACT NUMBER
FA8650-08-D-2806-0011

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
63216F

6. AUTHOR(S)
Gary B. Bessee, Scott A. Hutzler, and George R. Wilson

5d. PROJECT NUMBER
2480

5e. TASK NUMBER
07

5f. WORK UNIT NUMBER
248007P8

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

By:
Southwest Research Institute (SwRI®)
6220 Culebra Road
San Antonio, TX 78228

For:
Universal Technology Corporation
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Dayton, OH 45432-2600

8. PERFORMING ORGANIZATION REPORT NUMBER
08.14406

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory
Propulsion Directorate
Wright-Patterson Air Force Base, OH 45433-7251
Air Force Materiel Command
United States Air Force

10. SPONSORING/MONITORING AGENCY ACRONYM(S)
AFRL/RZPF

11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)
AFRL-RZ-WP-TR-2011-2084

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
Report contains color. PA Case Number: 88ABW-2011-3415; Clearance Date: 14 Jun 2011.

14. ABSTRACT
The overall aim of this effort was to provide fit-for-purpose testing and subject matter expertise to UTC and AFRL to support the evaluation of emerging synthetic aviation fuels. The report contains information on the evaluations of various synthetic aviation fuels including: Sasol IPK, R-8 HRJ SPK, R-8x HRJ SPK, Boeing Flight Fuels, Camelina HRJ SPK, Camelina/JP-8 (HRJ8), R-8/Jet A, Tallow HRJ SPK and Tallow/JP-8 (HRJ8). In addition, miscellaneous analyses including dielectric constants of the synthetic aviation fuels, lubricity, Ignition Quality Tests (IQT), JP-8+100 fuel/water separation tests (SAE J1488) and existent gums are reported. It is concluded that the testing performed to date provides strong evidence that blends composed of 50% synthetic aviation fuel (FT IPK and HRJ SPK) and 50% petroleum-based fuel will be more than adequate as drop-in replacements for current petroleum-based fuels.

15. SUBJECT TERMS
alternative fuels, synthetic aviation fuel, Fischer-Tropsch fuel (FT), fuel certification, hydrotreated renewable jet (HRJ), iso-paraffinic kerosene (IPK), synthetic paraffinic kerosene (SPK)

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT:	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON (Monitor)
a. REPORT	b. ABSTRACT	c. THIS PAGE			James T. Edwards
Unclassified	Unclassified	Unclassified	SAR	254	19b. TELEPHONE NUMBER *(Include Area Code)* N/A

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PREFACE

This report was prepared for the Universal Technology Corporation (UTC), 1270 North Fairfield Road, Dayton, Ohio, 45432-2600 under Contract Number F A8650-08-D-2806-0011 with the Air Force Research Laboratory's Propulsion Directorate (AFRL/RZ). Mrs. Michele Puterbaugh (Contractor, Universal Technology Corporation) was the project manager for this effort. Mr. James Klein, (Subcontractor, Klein Consulting LLC), was the technical leader in support of Dr. James T. Edwards, Senior Scientist, of the Fuels Branch (AFRL/RZPF), Energy/Power/Thermal Division, Propulsion Directorate, Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio. The research reported herein was performed by Southwest Research Institute, 6220 Culebra Road, San Antonio, TX and covers the period of 10 August 2008 through 9 November 2010. This effort was funded by the Air Force Research Laboratory.

1.0 Executive Summary

The overall aim of this effort was to provide fit-for-purpose testing and subject matter expertise to UTC and AFRL to support the evaluation of emerging synthetic aviation fuels. This report contains information on the evaluation of various synthetic aviation fuels including: Sasol IPK, R-8 HRJ SPK, R-8x HRJ SPK, Boeing Flight Fuels, Camelina HRJ SPK, Camelina/JP-8 (HRJ8), R-8/Jet A, Tallow HRJ SPK and Tallow/JP-8 (HRJ8). In addition to standardized testing, detailed studies were carried out in the following areas: dielectric constants, lubricity, ignition quality, fuel/water separation, and existent gums.

Although most of the fuels studied to date (particularly the 50/50 blends) would likely meet a standard jet fuel specification, each of the synthetic fuels in this study exhibit their own unique behavior imparted on the fuel by the particular feedstock. This further reinforces the need for fit-for-purpose testing to identify those unusual characteristics and to ensure that they are not significantly outside our current experience with petroleum-derived jet fuels.

In addition to this work, many others have contributed to the evaluation process in an effort to gain approval of these alternative fuels. Some of the blends containing fuel derived from sources such as Camelina and Jatropha, have already undergone successful flight tests. Based on the currently available data it appears that it is also possible to make a suitable HRJ SPK from oil derived from waste oils (fats, oils, and greases) and halophytes. This is consistent with existing data that indicates that the hydroprocessing of organic fats and oils produces high quality SPK regardless of the source.

For most of the synthetic fuels studied in this effort, the primary difference relative to a petroleum-derived fuel is the lack of aromatics. This would likely affect several properties such as material compatibility (elastomer swelling/shrinkage), tank gauging (density), and additive compatibility (solubility). However, it's likely that these are all minor issues that could be resolved and would not be a hindrance to the use of this fuel.

The cumulative work herein provides strong evidence that blends composed of 50% synthetic fuel (FT IPK and HRJ SPK) and 50% petroleum-based fuel will be more than adequate as drop-in replacements for current petroleum-based fuels.

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2.0 Introduction

The overall aim of this effort was to provide fit-for-purpose testing and subject matter expertise to UTC/AFRL to support the evaluation of emerging synthetic aviation fuels.

This report contains a compilation of results for selected tasks under contract #FA865008D2806TO0011 and should satisfy the following UTC subcontract agreements:

- 08S590001102C1
- 09S590001112C1
- 10S590001112C2

Three tasks under this effort have been reported separately and are not included in this document. They include the following:

- ***R-8 Rotary Fuel Injection Pump Wear***
  - SwRI Project No. 08-14406.03, G. Wilson and D. Yost
  - Dated January 2010
  - Sub Contract #09S590001113C1
- ***Change in Electrical Conductivity of Synthetic Fuel in Filtration and Storage Simulations***
  - SwRI Project No. 08-14406.02, G. Bessee
  - Dated January 2010
  - Sub Contract #09S590001111C1
- ***Analysis of Proprietary Fuels***
  - SwRI Letter Report, G. Bessee
  - Dated January 2009
  - Sub Contract #08S590001102C1

This report contains information on the following subjects:

- Evaluation of Synthetic Aviation Fuels
  - Sasol IPK
  - R-8 HRJ SPK
  - R-8x HRJ SPK
  - Boeing Flight Fuels
  - Camelina HRJ SPK and Camelina HRJ SPK / JP-8 (HRJ8)
  - R-8 HRJ SPK / Jet A
  - Tallow HRJ SPK and Tallow HRJ SPK / JP-8 (HRJ8)
- Miscellaneous Analyses
  - Dielectric Constants of Synthetic Aviation Fuel
  - FT and HRJ Evaluations (selected tests for comparison)
  - Lubricity
  - Ignition Quality Tests (IQT)
  - JP-8+100 Fuel/Water Separation Tests (SAE J1488)
  - Existent Gums

The following tasks are documented in full standalone reports included as appendices.

- Appendix B R-8 Report
- Appendix C R-8x Report
- Appendix E FT and HRJ Report
- Appendix F Dielectric Constant Report

3.0 Methods, Assumptions, and Procedures

3.1 Sample Terminology

Throughout this report, various means of identifying samples or fuel types are utilized. The Sample Identifiers, shown below in Table 1, Section 4.1, should be used as the primary sample reference. In figures and tables (where space is limited) and in the text to improve readability, shortened versions of the formal fuel descriptions may appear. For instance, "Camelina HRJ SPK," may simply be shortened to "Camelina" and is assumed to imply a neat fuel. Unless noted otherwise, blends denoted in this manner – "Tallow HRJ SPK / JP-8" – are assumed to be 50/50 volumetric blends of the synthetic and petroleum-based fuels. For those blends containing "JP-8" as the petroleum-based fraction, the JP-8 additives are assumed to have been added to the proper levels after the blend was prepared. In some cases, such a blend may be referred to as an "HRJ8" which again implies a 50/50 synthetic / petroleum blend containing JP-8 additives.

When this document was first prepared, HRJ or Hydroprocessed Renewable Jet was the favored terminology and is therefore used throughout. However, pending ASTM ballots sought to replace HRJ with HEFA or Hydroprocessed Esters and Fatty Acids. Therefore, the reader should be aware that HRJ and HEFA may appear synonymously in other documents.

3.2 Test Methods

Numerous analytical methods were used in the conduct of this testing. The large majority of those are ASTM "D" and "E" methods. Throughout this document, those methods are simply referenced by their method numbers, *e.g.* "D4052" and "E2716." Non-ASTM methods, such as Federal Test Methods (FTM) and those maintained by SAE, EPA, *etc.* are noted accordingly. Standardized test methods are not discussed at length in this document. These can be acquired from the presiding organizations and some are freely available via the Internet (*e.g.* FTM). Unless noted otherwise, it is assumed that the standardized tests were run as prescribed. New tests, modifications to standardized tests, or non-standardized tests are described in more detail below.

The primary fuel specifications referenced during the conduct of this work are indicated below. Many of these specifications are in flux as they are undergoing extensive modifications to accommodate the new emerging turbine fuels.

ASTM D1655	Standard Specification for Aviation Turbine Fuels
ASTM D4054	Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives
ASTM D7566	Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons
MIL-DTL-83133G	Detail Specification: Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37) (30 Apr 2010)
DEF STAN 91-91	Turbine Fuel, Aviation Kerosine Type, Jet A-1, NATO Code: F-35 (8 Apr 2008)

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3.3 Non-Standard Test Methods

The following sections describe specific methods utilized in this study which were either non-standardized or modified in some way to suit the needs of this effort.

3.3.1 Hot Surface ignition Temperature (FTM 791-6053)

The Hot Surface Ignition Temperature (HSIT) is measured according to Fed-Std-791 (6053). In the standard form of this test, the fuel is dripped onto a heated manifold at 1300°F. If ignition occurs then the test is a failure. SwRI runs a slightly modified procedure by attempting to bracket the actual ignition temperature. Starting from approximately 800°F, the temperature is increased in 50°F increments until failure is reached. The temperature is then reduced by 25°F and again tested. The lowest temperature at which ignition occurs is reported.

3.3.2 Specific Heat Capacity (ASTM E2716)

Having had difficulty in reproducing specific heat capacity data relative to other labs, SwRI acquired a new TA Instruments Q200 DSC. Based on discussions with Boeing and TA representatives, the reversing heat capacities of the test fuels were determined using modulated temperature DSC. This particular technique is documented in ASTM E2716 (rather than E1269). Both E2716 and E1269 provide general guidelines for performing specific heat capacity measurements but both maintain a lot of flexibility.

The specific test conditions used in this effort were as follows:

Calibration:	Synthetic Sapphire Disk (single point – mid range)
Temperature Range:	-40 to 180°C
Pans:	Tzero Aluminum Hermetic
Purge Gas:	Nitrogen
Purge Rate:	50mL/min
Heating Rate:	3°C/min
Sample Weight:	~10-15mg
Modulation:	0.716°C every 90s

3.3.3 Thermal Conductivity (SwRI)

There are actually many techniques used to measure thermal conductivity[1] (*e.g.* hot wire, transient plane source, guarded hot plate, laser flash diffusivity). Each has their own unique area of application with caveats that must be considered. The hot-wire technique is generally regarded as the preferred approach but was not readily available during this effort. It generally works well for liquids but it is not without its own issues. The effect of convection currents created during the experiment must be carefully handled. Prior to this effort, SwRI had recently acquired a TCi™ instrument from C-Therm Technologies (www.ctherm.com) which utilizes a modified transient plane source that uses heat reflectance similar to the hot-wire technique.

Following some initial investigations and discussions with the manufacturer, it was discovered that in order to more accurately determine thermal conductivity as a function of temperature, we would need to calculate it from thermal effusivity. The difference between thermal conductivity and thermal effusivity is subtle. Thermal conductivity is defined as a material's ability to conduct

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heat while thermal effusivity is defined as a material's ability to exchange thermal energy with its surroundings.

The TCi can measure both thermal conductivity and effusivity; however, in order to measure thermal conductivity as a function of temperature you must calculate it from thermal effusivity. For materials whose heat capacity and density are known at the desired temperature, a more accurate thermal conductivity can be obtained through thermal effusivity. Thermal effusivity is mathematically related only to thermal conductivity, density, and specific heat capacity. The TCi system also applies a temperature correction curve to effusivity. The overall effect is that the instrument is more responsive to heat capacity and temperature changes than the direct thermal conductivity measurement.

Thermal effusivity is defined as:

$$e = (k\rho C_p)^{1/2}$$

where,
e = thermal effusivity, (W $s^{1/2}$)/(m^2 K)
k = thermal conductivity, W/(m K)
ρ = density, kg/m^3
C_p = heat capacity, J/(kg K)

3.3.4 Surface Tension (ASTM D1331A)

To perform surface tension measurements, SwRI uses an automated tensiometer (K100 from Krüss). Although this unit incorporates a heating/cooling jacket, it typically isn't sufficient to reach the desired test temperatures in a reasonable amount of time. For that reason, samples are heated/cooled separately to within 5°C of the desired temperature and then transferred to the instrument. The heating/cooling jacket on the instrument is then used to maintain the temperature while a measurement is made (on the order of 1 minute).

3.3.5 Water Solubility vs. Temperature (SwRI)

This test utilizes a standard coulometric Karl Fischer water titrator but the sample preparation is unique. Unaware of any standard procedure to perform this test, SwRI developed the following approach:

- A sample composed of water (1-mL) and fuel (7-mL) are sealed in a 10-mL septum vial.
- The vial is gently shaken and then placed in an oven or cold box and allowed to equilibrate to the test temperature.
- After approximately four hours, the vial is gently shaken again. The vial is then allowed to rest for a period of at least 24 hours at the test temperature.
- After the rest period, a sample is carefully withdrawn through the septum using a syringe without agitating the vial contents. To the extent possible, this is done while maintaining the sample at the test temperature.
- The total water content of the sample is then measured by ASTM D6304.
- Lastly, the temperature of the fuel itself is measured using a thermocouple probe.

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3.3.6 Vapor Pressure (D6378)

True vapor pressure by the triple expansion method is relatively new so we have no comparative literature data at the present. To support this work, SwRI purchased an ERAVAP (manufactured by Eralytics™ GmbH) from Compass Instruments. The instrument supports two modes of operation: single point analysis and unattended operation over a range of temperatures. The instrument can determine vapor pressures in the range of 0-120°C.

For this effort, we chose to operate in the unattended mode for two reasons: 1) to be able to measure more points in a short amount of time, and 2) to conserve fuel. In some preliminary testing, it was noted that samples run in the single point mode gave slightly lower values (~5-10%) than those run in the unattended mode. It's still unclear which method gives the most accurate result. For single component samples, like pentane, both methods yield highly accurate and repeatable results. One consideration is that repeated sampling of the same container may lead to loss of light ends which may be affecting the data. This was yet another reason behind the decision to sample once and allow the instrument to operate in unattended mode.

3.3.7 Dielectric Constant (SwRI)

At the start of this effort little was known or documented about measuring dielectric constant specifically for aviation fuel. The only group known at the time to be conducting this measurement was Goodrich Sensors and Integrated Systems, Inc. To help support AFRL, Goodrich agreed to loan SwRI one of their k-cells. SwRI invested in the necessary peripheral equipment and subsequently adopted a variation of the Goodrich procedure which is outlined below.

3.3.7.1 Apparatus

- k-cell
- k-cell holder
- Andeen-Hagerling Ultra-Precision Capacitance Bridge (2700A), 50Hz-20kHz
- Thermocouple
- Thermocouple reader

The "system" shall refer to the combination of the capacitance bridge and k-cell.

3.3.7.1.1 Materials

- 1000mL Beaker
- Isopropanol (Grade - Certified ACS Plus or better)
- Cyclohexane, HPLC Grade or better
- Solvent bottle

3.3.7.2 Cleaning the k-cell

To clean the k-cell, use the following procedure:

1) Disconnect the k-cell from the capacitance bridge
2) Allow the k-cell to drain thoroughly
3) Perform an initial flush of the k-cell using isopropanol from a solvent bottle
4) Allow the k-cell to drain thoroughly

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5) Submerge the k-cell into a beaker filled with isopropanol. Do not submerge the BNC connectors of the k-cell.
6) Remove the k-cell from the isopropanol.
7) Repeat steps 5-6 two more times
8) Allow the k-cell to drain thoroughly.
9) Submerge the k-cell into a second beaker filled with isopropanol. Do not submerge the BNC connectors of the k-cell.
10) Remove the k-cell from the isopropanol.
11) Repeat steps 9-10 two more times
12) Allow the k-cell to drain thoroughly.
13) Dry the k-cell using a stream of dry, oil-free air. The k-cell should be kept vertical so that fluid can drain.

3.3.7.3 System Verification

When verification of the system is required, the following procedure shall be followed.

1) Determine the dielectric constant of cyclohexane at ambient temperature (18-25°C) according to the procedure in Section 3.3.7.6.
2) The dielectric constant of cyclohexane shall not deviate by more than ±0.01 units from those established by the following curve:

$$\varepsilon_r = -0.00162T + 2.0564$$

where,
ε_r = dielectric constant
T = temperature (°C)

3.3.7.4 Instrument Calibration

Calibration of the capacitance bridge shall only be performed by the manufacturer.

3.3.7.5 Sample Preparation

Other than equilibrating the sample to the appropriate test temperature, no sample preparation is required in the normal execution of this procedure.

3.3.7.6 Test Procedure

The following procedures are used to measure the capacitance of an air or a liquid sample. Refer to the operating manual for instructions on using the capacitance bridge. For all procedures, allow the capacitance bridge at least 30 minutes of warm-up time prior to performing a measurement.

Dielectric Constant of Air

1) Ensure that the k-cell has been cleaned as described above.
2) Connect the k-cell to the capacitance bridge (the cables are labeled to match the inputs on the rear of the bridge)
3) Set the desired frequency of the capacitance bridge (nominally 400Hz or 10kHz)
4) Air measurements should be performed at room temperature (18-23°C). Allow the k-cell and its holder to equilibrate to the room temperature for at least 30 minutes prior to running.
5) Place the k-cell in its holder.

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6) Collect and record three separate capacitance and temperature readings within two minutes. Alternatively – monitor the capacitance in continuous mode until the fourth decimal place becomes steady for at least 1 minute. This is often difficult if the room temperature is not constant. Collect three readings over a three minute a period.
7) Calculate the average air capacitance according.

Dielectric Constant of a Liquid Sample

1) Test temperatures may range from -40°C to 80°C.
2) Ensure that the k-cell has been cleaned as described above.
3) Connect the k-cell to the capacitance bridge (the cables are labeled to match the inputs on the rear of the bridge)
4) Set the desired frequency of the capacitance bridge (nominally 400Hz or 10kHz)
5) Under hot conditions
    a. Equilibrate the k-cell, k-cell holder, and sample separately to the desired temperature.
    b. Transfer the equilibrated sample to the equilibrated k-cell holder.
    c. Place the equilibrated k-cell in its holder.
    d. Allow an additional 10-20 minutes of equilibration or until stable.
6) Under cold conditions
    a. Assemble the k-cell, k-cell holder, and sample under ambient conditions in a low humidity environment (50% non-condensing).
    b. Equilibrate the k-cell, k-cell holder, and sample together to the desired temperature. This prevents humid air from condensing out on the k-cell and k-cell holder which will affect the results.
7) Collect and record three separate capacitance and temperature readings within two minutes. Alternatively – monitor the capacitance in continuous mode until the fourth decimal place becomes steady for at least 1 minute. This is often difficult if the temperature is not constant. Collect three readings over a three minute period.
8) Calculate the dielectric constant as described below.

3.3.7.7 Calculations

The dielectric constant, ε_r, is calculated as the ratio of the capacitance of the fuel-wetted k-cell to the capacitance of air (dry k-cell):

$$\varepsilon_r = C_{sample} / C_{air}$$

where,
ε_r = dielectric constant
C_{sample} = capacitance of the sample (pF)
C_{air} = capacitance of air (dry cell) (pF)

The capacitance of air, C_{air}, is measured once per day, in triplicate, prior to samples being run. The final value is computed as an average of the three runs and used in all subsequent calculations for samples run that day.

3.3.7.8 Data to Be Recorded

1) Capacitance of air (in triplicate) at ambient temperature (pF)
2) Air temperature (°C)
3) Capacitance of the sample (in triplicate) (pF)
4) Sample temperature (°C)
5) k-cell holder ID#
6) Thermocouple S/N

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7) Thermocouple reader S/N

Capacitance values shall include all digits displayed by the capacitance bridge.

3.3.8 Elastomer Evaluation (SwRI)

The o-ring elastomer compatibility test, adapted from ASTM D1414, is a useful screening tool when a full material compatibility test is cost prohibitive. Three types of o-rings are used in this test - fluorosilicone, nitrile, and viton. Four o-rings are evaluated for each test for statistical purposes. Prior to soaking in fuel, the elastomers used for the volume change measurement (ASTM D1414/D471) are sent to the lab for pre-measurement. Since the tensile strength test (ASTM D1414/D412) is destructive, these baseline measurements are based on a different set of o-rings measured previously and assumed to be the nominal value for this lot of o-rings. The o-rings are then placed on a stainless steel rack, covered in test fuel (approximately 200mL), and soaked for 7 days in the dark at room temperature. Once the soak period is complete, the samples are returned to the lab where they are tested for tensile strength and volume change.

3.3.9 SAE J1488 (Fuel/Water Separation)

Per ASTM D4054 (Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives), the candidate fuels should have no impact on coalescer filtration relative to a typical Jet A. The standard method for evaluating filtration performance for aviation use is API/EI 1581 5th Edition. A single element test (SET) is performed to evaluate the water and dirt removal characteristics, which includes the following sequence of tests:

- water challenge at 100-ppm for 30 minutes
- dirt challenge for 75 minutes
- 100-ppm water challenge for an additional 150 minutes
- 3% water challenge.

The test equipment is well defined in this standard but a test typically requires the use of approximately ***12,000*** gallons of test fuel. Testing on this scale requires a large facility and therefore limits its widespread application. For our discussions, the main component of interest is the 2,950-rpm centrifugal pump. During the water challenge, water is injected upstream of this pump so that it generates a consistent emulsion.

The challenge was how to evaluate the water removal characteristics of alternative aviation fuels given very limited quantities of test fuel. A test method utilized by the automotive industry is Society of Automotive Engineers (SAE) J1488 (Emulsified Water/Fuel Separation Test Procedure). This test method utilizes a 3,500-rpm centrifugal pump to generate a fuel/water emulsion to challenge the test filter. The water challenge is 2,500-ppm of water for 150 minutes. Since the pumps were similar, the SAE J1488 method seemed like a reasonable alternative to determine if any of the candidate aviation fuels exhibited water removal issues. A typical J1488 test requires approximately 50-L of fuel which would typically be available even in pre-production runs of fuel.

Since most automotive fuel filters utilize hydrophobic barrier filtration (due to cost constraints), the next challenge was to find an automotive fuel/water separator similar to what is utilized in the API/EI 1581 test method. The solution was found in the filtration system used on the U.S. Army M1A1 battle tank. Since the tank utilizes a turbine engine, the original filtration design was similar to that used for the aviation industry. The housing utilizes two coalescers and one

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separator in the housing. The flow patterns are similar in that the flow is inside-out for both the API/EI 1581 coalescers and M1A1 filters and the flow is outside-in for the separators. Both coalescer technologies use glass to generate larger water droplets and Teflon separator screens to repel any water that gravity does not remove. Through years of experience, these filters are known to SwRI to provide good fuel/water separation for aviation fuel under normal operating conditions. Collective experience has shown that it is possible to fail this test using these filters under the right conditions of fuel type and additive treatment.

The intended purpose of the two test methods is somewhat different. The primary intent of API/EI 1581 is to qualify aviation fuel filters while J1488 is primarily used to determine water removal efficiency (WRE) for a given filter. These are handled differently by each method. API/EI 1581 uses the Aqua Glo ® test so it only measures dissolved water. The J1488 test measures only free water using a Karl Fisher coulometric water titrator (the fuel saturation limit is subtracted out of the total water content). Strictly speaking, there are no pass/fail criteria when applying the J1488 test in this manner. The test is simply used as a screening tool to identify obvious signs of fuel/water separation issues. For instance, if a test were run that resulted in a 50% WRE, that should cause some immediate concern and additional investigations would be warranted. That's not to say that a fuel that gives a >95% WRE by J1488 will always pass the API/EI 1581 test but it provides some confidence that the fuel doesn't have any significant fuel/water separation issues.

In conclusion, although the J1488 method does not incorporate particulate filtration, several parts of the test method bear a strong resemblance to API/EI 1581. With a moderately severe water challenge and a filtration system design nearly identical to that used in API/EI 1581, SAE J1488 was offered as a good screening methodology for alternative aviation fuels. ***We should strongly note that this test is not recommended as a substitute but rather as a screening tool when fuel volumes are limited and testing otherwise would be impossible.***

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4.0 Results and Discussions

The following sections provide details on specific tasks under this effort. For sub-reports, the reader is directed to the appropriate appendix for further reading.

4.1 Sample Cross-Reference

The samples in Table 1 were the primary focus of this effort and are discussed throughout the remainder of the document and in sub-documents. Other samples are identified where appropriate. Other than the Boeing Flight Fuels (CL09-0500 to 0503), all synthetic fuels were provided by AFRL. Information on the production of the Boeing Flight Fuels is documented elsewhere by Boeing[2]. In some cases (noted in the table) Jet A for blending was provided by SwRI. Where available, certificates of Analysis (CofA) are provided in Appendix N.

Table 1. Sample Identifiers

POSF#	SwRI CL#	Description
5642	CL09-0268	Sasol FT-IPK
5469	CL09-0324	R-8 HRJ SPK (Lot 1)
--	CL09-0325	R-8 HRJ SPK / Jet A Blend {The Jet A was provided by SwRI from fuel on-hand at its API Facility}
--	CL09-0500	Jatropha / Algae Blend (Boeing)
5674	CL09-0501	50/50 Bio-SPK / Jet A Blend (JAL Blend, Boeing) Bio-SPK* portion from Camelina/Jatropha/Algae
5675	CL09-0502	50/50 Bio-SPK / Jet A Blend, (CAL Blend, Boeing) Bio-SPK* portion from Jatropha/Algae
5673	CL09-0503	50/50 Bio-SPK / Jet A Blend (ANZ Blend, Boeing) Bio-SPK* portion from Jatropha
5470	CL09-0636	R-8x HRJ SPK
6152	CL10-0278	Camelina HRJ SPK
5469	CL10-0326	R-8 (second batch received in 2010)
6184	CL10-0327	Camelina HRJ SPK/JP-8 (POSF6183/POSF4751)
--	CL10-0428	R-8 HRJ SPK/Jet A {The Jet A was acquired by SwRI from Valero specifically for blending with the R-8. A CoA is provided herein.}
--	CL10-0429	Jet A for R-8 Blend (Valero)
5140	CL10-0687	TS-1
6308	CL10-0773	Tallow HRJ SPK
6406	CL10-0932	Tallow HRJ SPK/JP-8
4658	CL09-0342	Jet A

* To our knowledge, the Bio-SPK fuels were produced according to UOP's Renewable Jet Fuel Process

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4.2 Evaluation of Synthetic Aviation Fuels

4.2.1 Sasol IPK

A subset of selected tests from the Fit-For-Purpose test matrix (ASTM D4054) and aviation specifications (ASTM D1655) were performed on the Sasol IPK. The highly isomerized nature of the fuel manifests itself in some fuel properties that tend to lie at the extremes of what might be considered a typical aviation fuel. However, none of the differences appear excessive to the point of failure.

The test results for the Sasol IPK can be found in Appendix A (page A-1). Results from the fuel are also included in the discussion below on critical fuel properties.

4.2.2 R-8 HRJ SPK (2009)

Please see Appendix B (page B-1) for the full R-8 report.

4.2.3 R-8x HRJ SPK

Please see Appendix C (page C-1) for the full R-8x report.

4.2.4 Boeing Flight Fuels

The fuels provided by Boeing for analysis were those used in recent flight tests by three major airlines: Air New Zealand (ANZ), Continental Airlines (CAL), and Japan Airlines (JAL). Each of the fuels was a 50/50 blend of Bio-SPK and petroleum-based jet fuel. The Bio-SPK ranged from neat biofuel to a blend of several biofuels. The biofuels being investigated were those derived from camelina, jatropha, and algae.

The test results for the flight fuels are provided in Appendix D (page D-1). Many of the critical properties are discussed in detail below and plotted against the other fuels in this study for comparison. These fuels showed no outward signs of unusual properties relative to the various aviation fuel specifications.

4.2.5 FT and HRJ Evaluation

Please see Appendix E (page E-1) for a comparative evaluation of selected FT and HRJ fuels.

4.2.6 Dielectric Constants of Synthetic Aviation Fuel

Please see Appendix F (page F-1) for a comparative evaluation of the dielectric constants of petroleum and synthetic aviation fuels.

4.2.7 R-8 HRJ SPK/Jet A Evaluation

A second shipment of R-8 HRJ SPK (POSF5469, CL10-0326) was received from AFRL in February 2010. This batch of R-8 was from the same pilot production as the R-8 tested in 2009. After acquiring a new batch of Jet A (CL10-0429) from Valero, a 50/50 R-8/Jet A blend was

prepared (CL10-0428) and subjected to a complete fit-for-purpose analysis. The results of this testing can be found in Appendix H.

Noteworthy observations:

- The blend gave extremely high lubricity values but this is expected since the fuel contained no lubricity additives.
- The upper (UEL) and lower (LEL) explosion limits and the minimum ignition energy (MIE) showed some of the lowest values observed to date. The lab that runs the MIE test reported that there was condensation inside the vessel indicative of incomplete vaporization at 100°C. Similar observations were noted in previous tests on R-8.
- After completing the fuel/additive compatibility test, some additive separation was noted. Small droplets were seen in the bottles containing FSII and the additive cocktail (MDA, AO, SDA, CI/LI, and FSII). A subsequent re-run of those samples showed no signs of separation. We suspect this may have resulted from incomplete initial blending.

4.2.8 Camelina HRJ SPK and Camelina HRJ8

Samples of neat Camelina (POSF6152, SwRI CL10-0278) and a 50/50 Camelina/JP-8 (POSF6184, SwRI CL10-0327) blend were provided by AFRL for fit-for-purpose testing. The results of this testing can be found in Appendix I. Relative to other HRJ samples, both the neat and blended Camelina produced some results that caused it to stand out from the other samples.

Noteworthy Observations:

- Camelina
    - Low density
    - Low viscosity
    - Low boiling point distribution
    - High vapor pressure
- Camelina/JP-8
    - Low viscosity
    - Surface tension showed less of a response to temperature change than the other samples.

Some of these differences are illustrated below.

4.2.9 Tallow HRJ SPK and Tallow HRJ8

A sample of neat Tallow (POSF6308, SwRI CL10-0773) and a 50/50 Tallow/JP-8 (POSF6406, SwRI CL10-0932) blend was provided by AFRL. Limited testing was performed on the neat Tallow in advance of the arrival of the blend. Those results can be found in Table G-4 of Appendix G.

The results of the Tallow/JP-8 evaluation can be found in Appendix J. While most of the common fuel properties appeared unremarkable, three observations stood out as noteworthy:

- The Tallow/JP-8 blend seemed to have an affinity for water at elevated temperatures.
- At elevated temperatures, the electrical conductivity was unusually high relative to other samples.

- Similar to the R-8/Jet A blend, the Tallow/JP-8 blend also showed signs of separation with FSII and the additive cocktail. While the FSII appeared to stay in solution on a subsequent run the additive cocktail continued to show signs of additive separation.

4.3 Miscellaneous Fuel Testing

Over the course of the project, some requests were made for miscellaneous testing of fuel samples. Testing was performed on selected samples by the following methods:

- High Frequency Reciprocating Rig (HFRR) – D6079
- Scuffing Load BOCLE – D6078
- Ignition Delay and Derived Cetane Number (by IQT™) – D6890

The results for these miscellaneous sample evaluations can be found in Appendix G (page G-1).

4.3.1 Comparative Lubricity Data

Also included in Appendix G (Table G-5) is a comparative evaluation of selected fuels for the three different lubricity measurements: HFRR (D6079), SLBOCLE (D6078), and BOCLE (D5001). These evaluations were performed to provide a baseline for comparison among various fuel types including petroleum-derived fuel, IPK, HRJ, and blends thereof.

One observation is that some differences can be seen between these results and the results from the same testing that was performed when the samples were first received. Many of these differences are within the repeatability of the respective method so no conclusive comments can be made regarding the variability. Fuel lubricity is very sensitive to handling and storage and can change over time. Some containers, such as plastics, can improve the lubricity of a fuel by leaching material from the walls while others can reduce the lubricity through a loss of additive to the walls. Although we cannot control the containers in which the samples are received, we traditionally store samples in glass bottles or epoxy-lined metal cans to minimize the effect on the fuel while in storage.

4.3.2 Existent Gums

As part of the effort among government and industry groups to have HRJ approved for use and included in ASTM D7566, a request was made to have a variety of neat HRJ fuels analyzed for existent gums (ASTM D381). Once the fuels were selected, the existent gum content (using steam) was determined twice (in duplicate). The results of that testing can be found in Appendix G Table G-6. Although all of these fuels were shown to have very low existent gum content when originally analyzed (by SwRI and others) at least two of the fuels, R-8x and Camelina, showed an increase in gum content. After the second set of tests were complete, the gum residues were washed with carbon disulfide and sent to UOP for analysis on a high-resolution mass spectrometer (HRMS). Those results showed the presence of high molecular weight natural products, such as cholesterol-like compounds and squalene, which had survived the hydro-treating process. Over time, these had likely concentrated in the sample container. It's also noteworthy that the R-8x sample was taken from a nearly empty can and probably not representative of the original fuel.

4.3.3 Fuel/Water Separation – JP-8+100

Seven samples of JP-8+100 and one sample of JP-8, Table 2, were received for fuel/water separation testing by SAE J1488. The JP-8+100 samples contained various types of +100 additive at a treat rate of 256-mg/L. Where several +100 additives are indicated, equal parts of each were added for a combined total of 256-mg/L.

The worksheet for each test can be found in Appendix M (page M-1). Overall, the time-weighted average water removal efficiency (TWA WRE) was 100% for all samples. This suggests that these combinations of +100 additive should not interfere with the sample's ability to separate water when used with a typical filter/separator designed for aviation fuel.

Table 2. JP-8+100 Samples

SwRI Sample ID	Description
10-1225	Test#1, POSF6839, w/P41, P47, P50, JP-8+100
10-1226	Test#2, POSF6835, w/P44, JP-8+100
10-1227	Test#3, POSF6834, w/P41, JP-8+100
10-1228	Test#4, POSF6836, w/P47, JP-8+100
10-1229	Test#5, POSF4751, JP-8
10-1230	Test#6, POSF6837, w/P50, JP-8+100
10-1231	Test#7, POSF6838, w/P39, P41, P44, P47, P50, JP-8+100
10-1232	Test#8, POSF6833, w/P39, JP-8+100

4.4 Discussion of Selected Fuel Properties

This section contains a discussion of selected fuel properties with particular focus on the flight-critical fuel properties. Where possible, fuels evaluated during this study are compared with expected values based on historical data (CRC Handbook of Aviation Fuel Properties[3], CRC World Fuel Sampling Program[4]). This serves to highlight some of the distinct characteristics inherent to some of the fuels and illustrate the expected extremes that may be encountered when dealing with the emerging synthetic fuels.

4.4.1 Distillation (D86)

Distillation values for selected fuels in this study are shown in Figure 1. The neat synthetics generally appear to have higher boiling points on average relative to the 50/50 blends. This corroborates with other volatility-related measurements such as vapor pressure. However, the neat Camelina appears to have a very low boiling range. This information seems to be corroborated by other data such as vapor pressure.

4.4.2 True Vapor Pressure (D6378 Triple Expansion)

The samples shown in Figure 2 were all measured in the unattended operation mode from 0-120°C with 10°C increments. In this mode the instrument draws in a sample, equilibrates to the next test temperature, and carries out the triple expansion method. The SwRI Jet A generally agrees with the CRC Aviation Handbook data which was determined by calculation from Reid vapor pressures. The slightly elevated low-temperature vapor pressure of the "ANZ" blend may

be valid and is further supported by the lower boiling point temperatures seen in the D86 analysis. The neat Camelina exhibited an elevated vapor pressure at high temperature also supported by a low boiling range in the D86. Assuming this data to be accurate, the alternative fuels in this study generally fall near or between the petroleum-derived Jet A and TS-1. This would suggest that the alternative fuels and blends thereof might exhibit similar behavior to fuels already approved and in everyday use.

4.4.3 Density (D4052)

Density values for the test fuels are shown in Figure 3. There is good agreement between SwRI's Jet A and the CRC Aviation Handbook Jet A data. The neat Camelina stands out with an exceptionally low density. As expected, the 50/50 blends generally lie midway in between the neat synthetic and petroleum-based samples. No physical or chemical data is available on the individual fuels used in the Boeing Fuel Blends (JAL, ANZ, CAL).

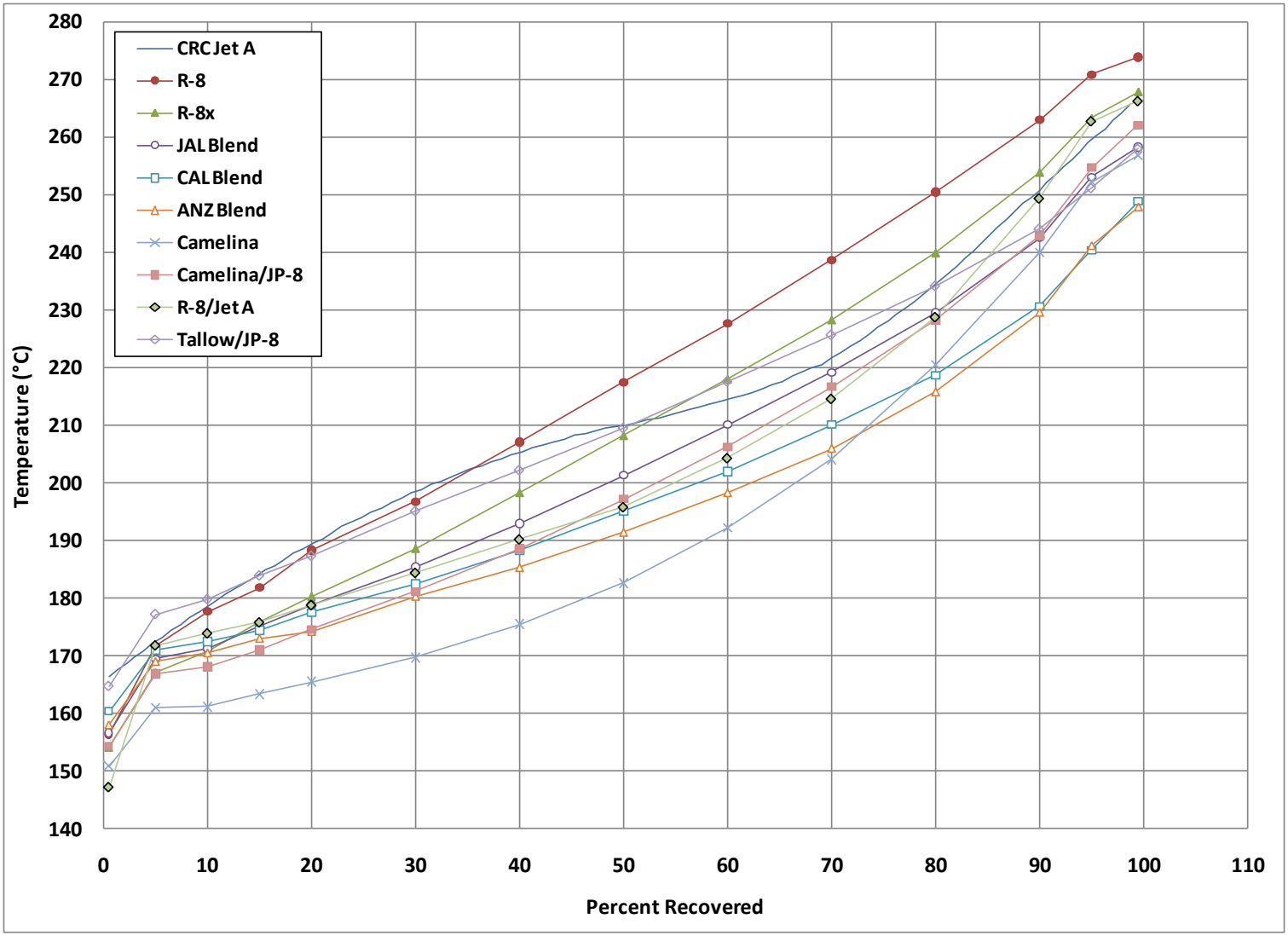

Figure 1. Distillation (D86)

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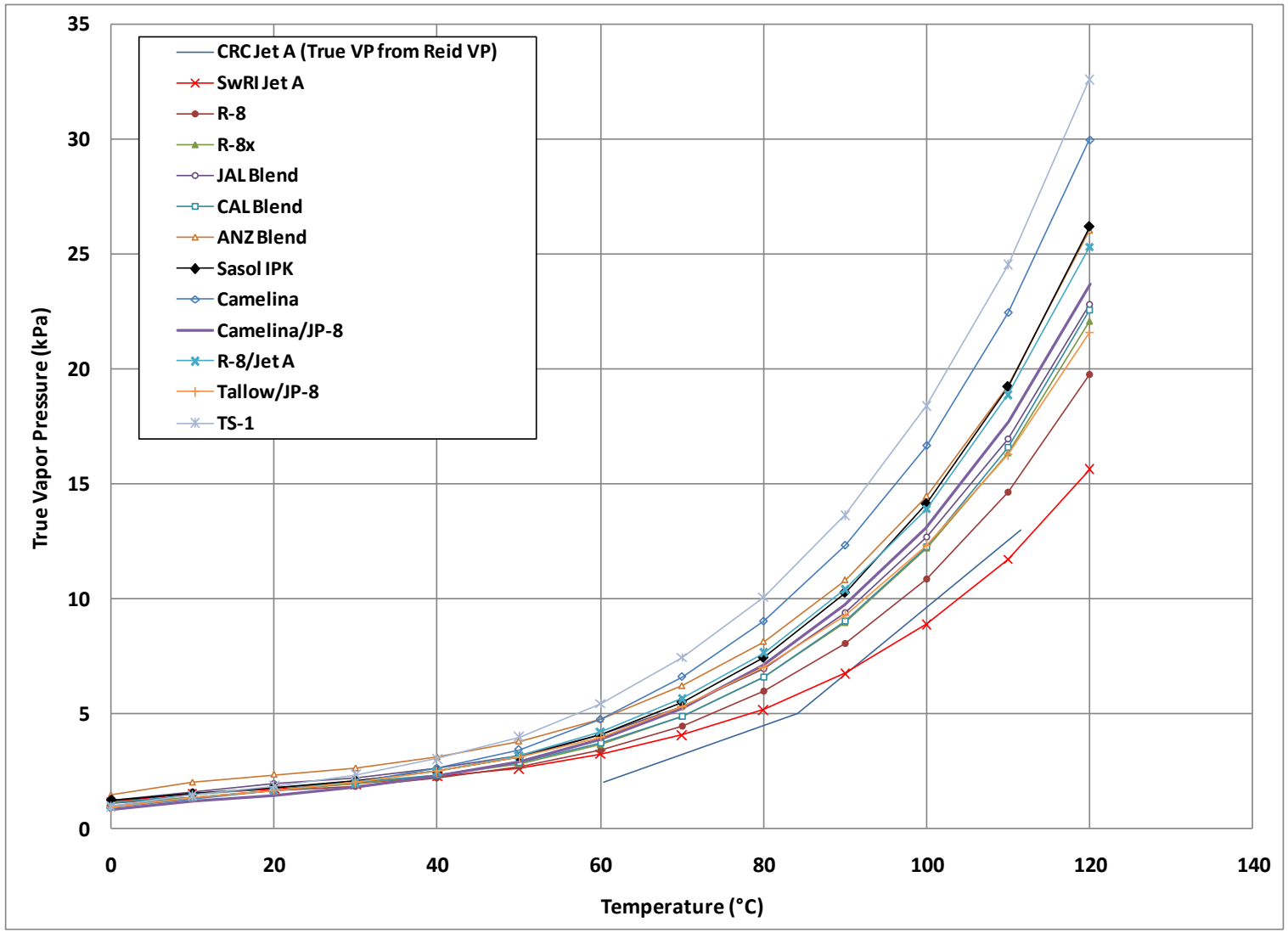

Figure 2. True Vapor Pressure (D6378)

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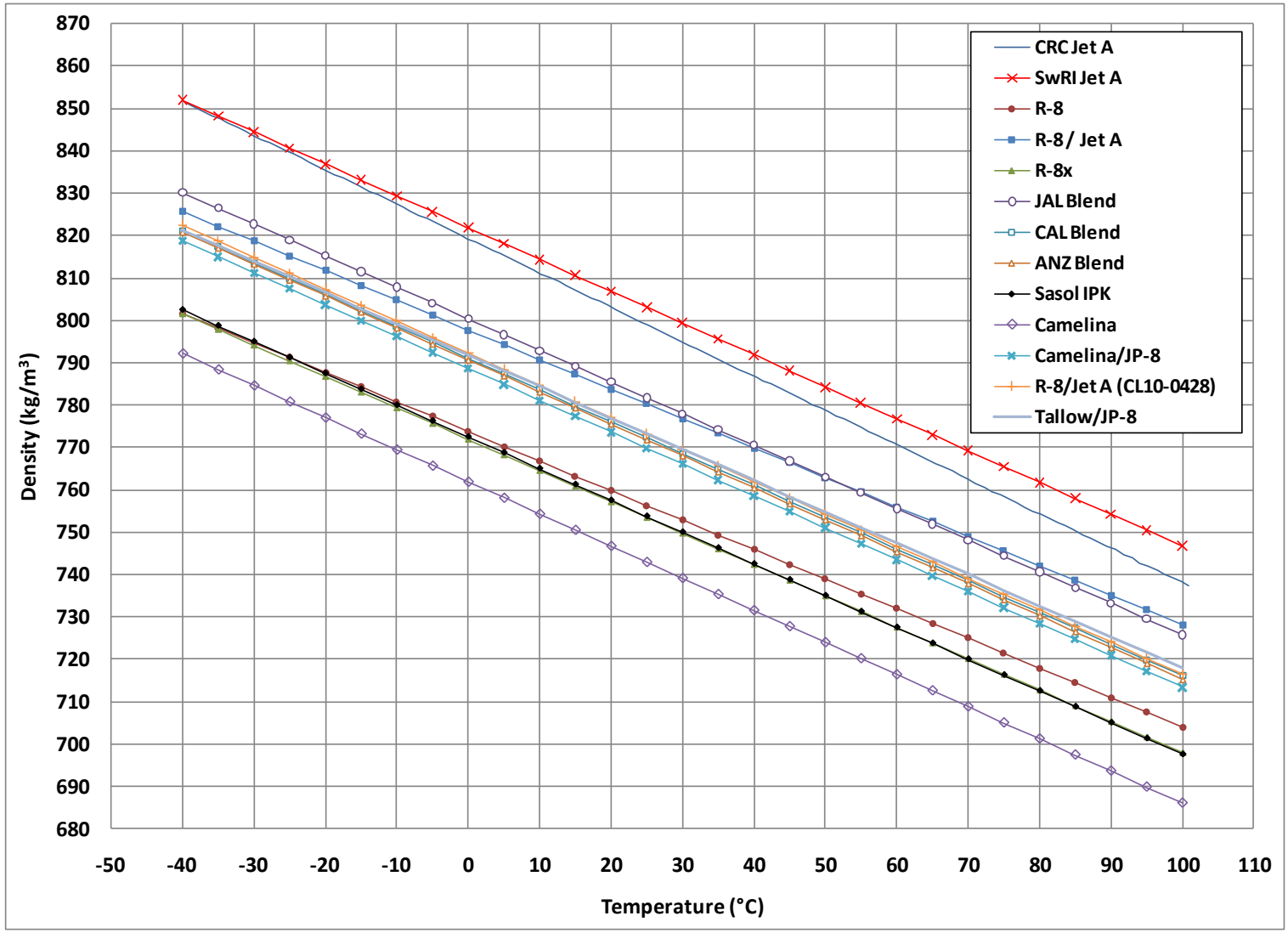

Figure 3. Density (D4052)

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4.4.4 Isothermal Tangent Bulk Modulus (D6793)

ASTM D6793 provides a procedure to determine two types of isothermal bulk modulus: secant and tangent. The isothermal secant bulk modulus is measured directly using a classical P-V-T measurement and the isothermal tangent bulk modulus is calculated from that data. In the literature, most of the bulk modulus data for fuel is based on speed-of-sound measurements and called isentropic or adiabatic bulk modulus. An internet literature search found some evidence that the speed-of-sound measurements produce "adiabatic tangent bulk modulus," although we've been unable to back that up with a credible source. Indeed, we've found that the isothermal tangent bulk modulus closely resembles the adiabatic measurements found in the literature. The CRC Handbook of Aviation Fuel Properties states that the relationship between these different techniques is:

$$B_s/B_t = C_p/C_v = \gamma$$

where,

$C_p/C_v = \gamma$ is the ratio of specific heats for the fuel
B_s = adiabatic (isentropic) bulk modulus (based on speed of sound)
B_t = isothermal bulk modulus

CRC suggests that gamma ≈ 1.15 for a typical jet fuel (this value has not been independently verified but might vary anywhere from 1.0-1.15). This would require the isothermal values to be up to 15% lower than what is typically found in the literature. To date, our values for isothermal tangent bulk modulus are actually slightly higher than those reported by CRC. We feel our isothermal data is higher than what would normally be expected although we've been unable to find a source for the positive bias.

The adiabatic bulk modulus can be calculated from speed-of-sound as:

$$B_s = \rho c^2$$

where,
B_s = adiabatic (isentropic) bulk modulus, Pa
ρ = density, kg/m^3
c = speed-of-sound, m/s^2
Using a nominal density value for Jet A yields approximate values in the range of 1200-1250 m/s for the CRC data. This seems to be low relative to other literature sources for similar fuel, which give values in the range of 1300-1400 m/s. At the time of this writing, SwRI was working on instrumentation for measuring speed-of-sound so a direct comparison can be done in the near future. A few measurements made to date have produced a value of approximately 1300-m/s for a petroleum-based Jet A.

The isothermal tangent bulk modulus data at 30°C (Figure 4) and 60°C (Figure 5) is presented below. The observed trends generally show that the petroleum-based Jet A gives the highest bulk modulus value while the neat synthetics tend to lie at the lower extremes. The 50/50 blends fall between those values.

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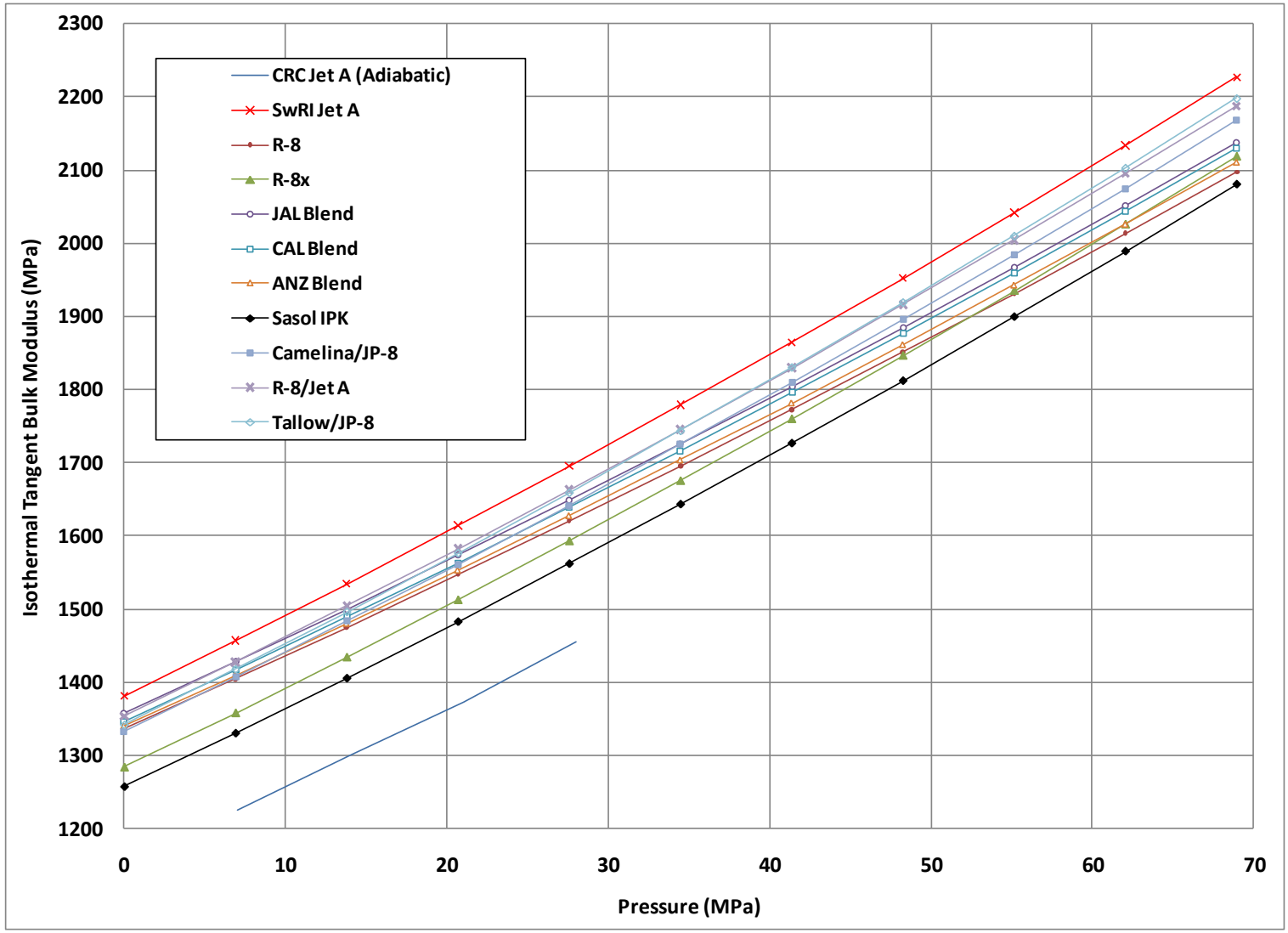

Figure 4. Isothermal Tangent Bulk Modulus (D6793) – 30°C

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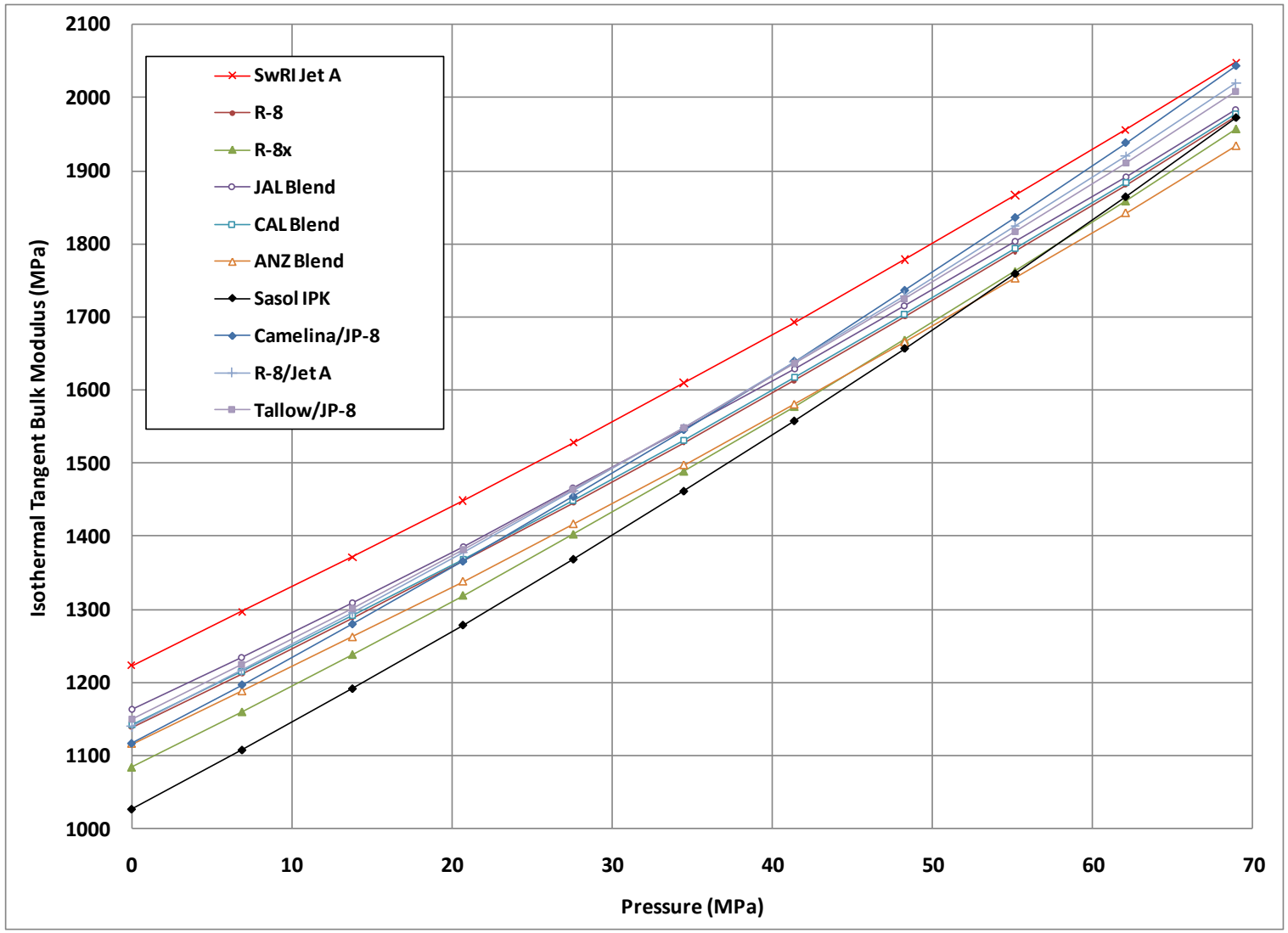

Figure 5. Isothermal Tangent Bulk Modulus (D6793) – 60°C

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4.4.5 Dielectric Constant

Dielectric constant varies inversely as a function of temperature and shows distinguishable differences between fuel types (Figure 6). Relative to density (Figure 7), the differences between fuel types are minimal. This data was generated by measuring the dielectric constant at a series of temperatures between -40°C and 80°C. The density at these temperatures was determined by extrapolation from the density curves for the particular fuel. A linear curve fit of the corresponding data allowed the dielectric constant to be plotted across a range of densities or temperatures.

The variation across a range of densities may still be significant. Aircraft may now see fuels ranging from 100% petroleum-based fuel to 50/50 blends whose densities may vary by 30 kg/cm^3 or more. The impact of this difference on the aircraft tank gauging system should be considered. This data was generated at a frequency of 400Hz for comparison to historical data. Additional testing was performed at frequencies up to 12 kHz with no significant effect on dielectric constant. This may not be true for all dielectric cells and fuels containing excessive water.

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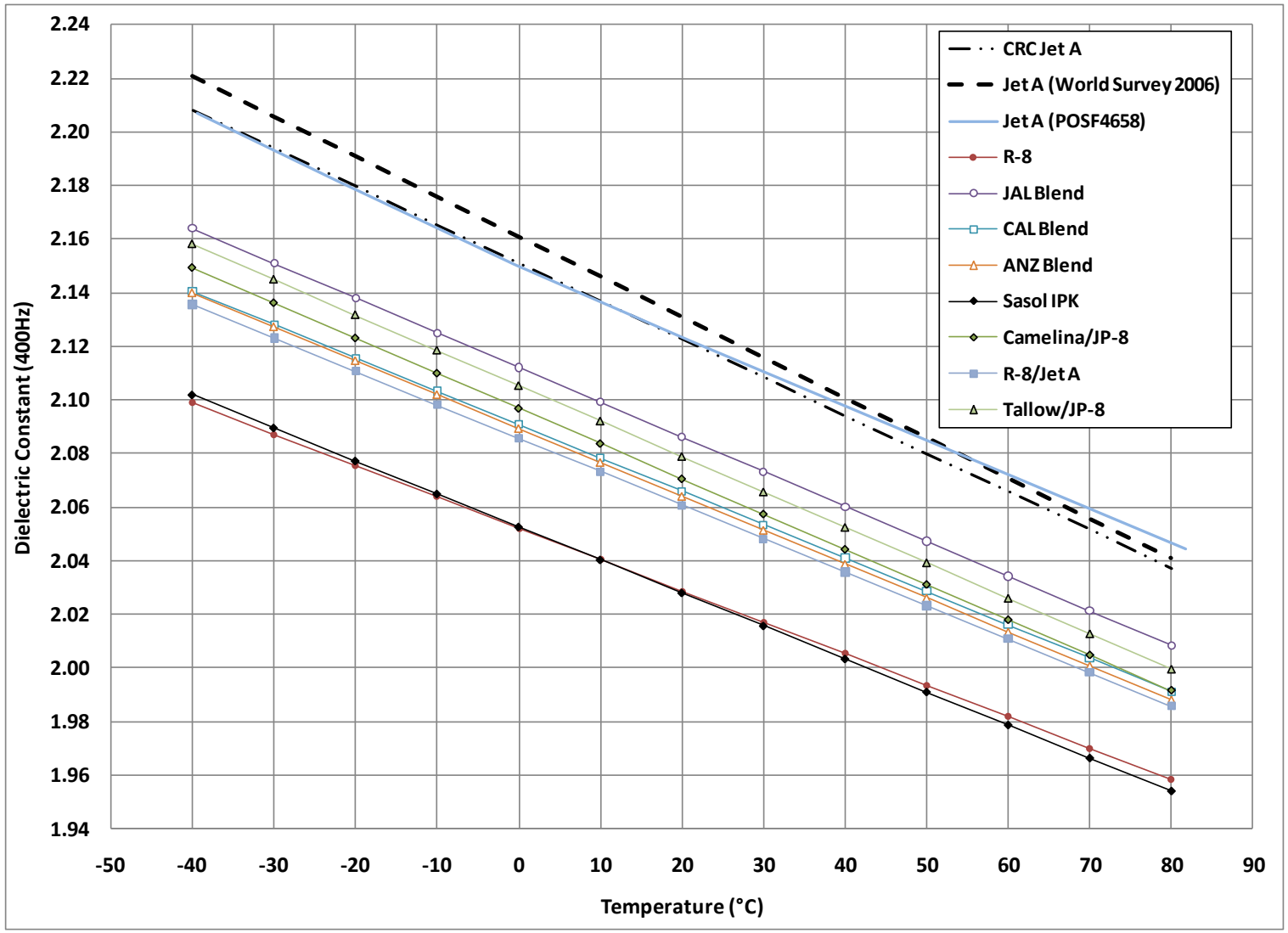

Figure 6. Dielectric Constant vs. Temperature

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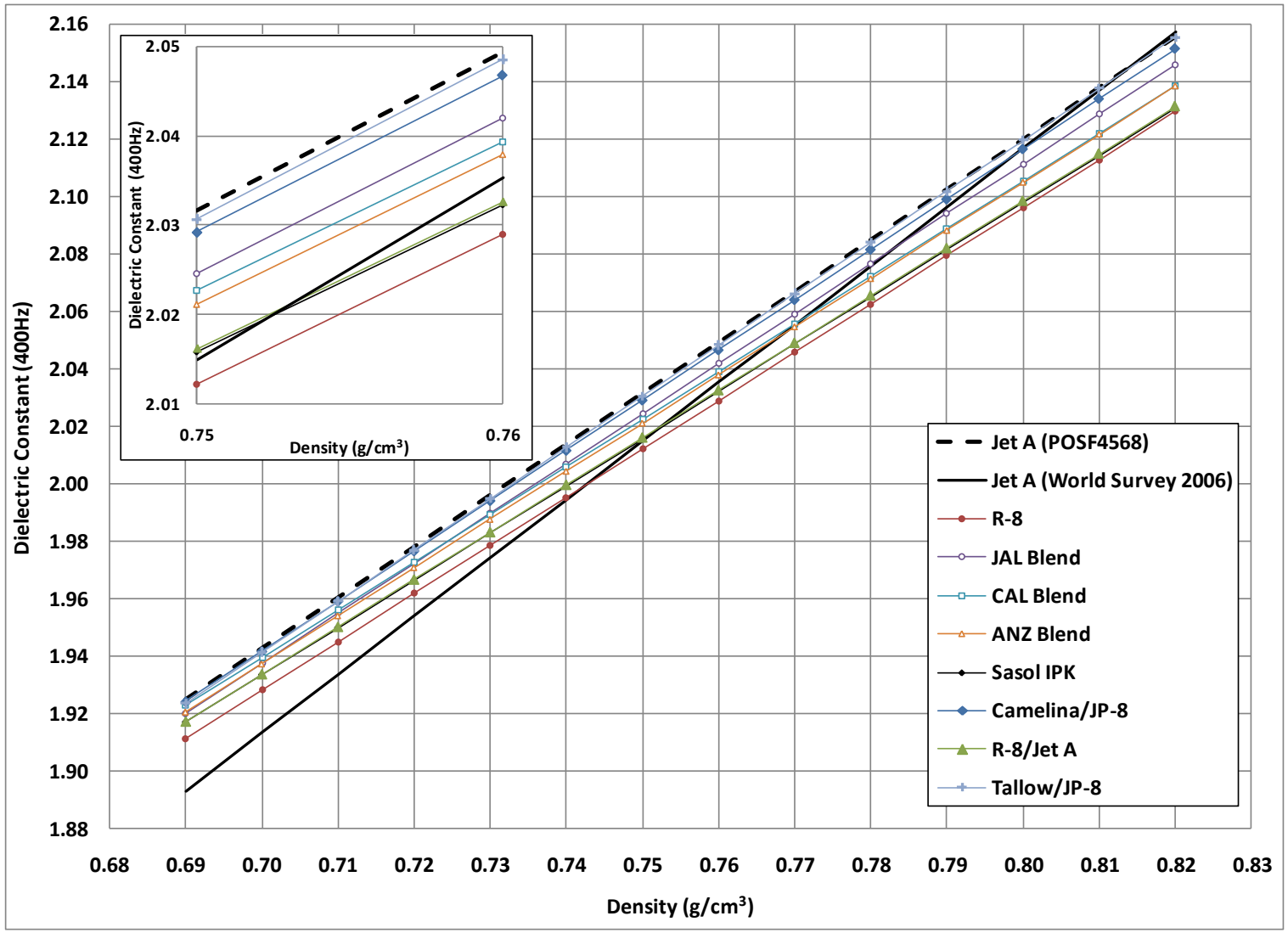

Figure 7. Dielectric Constant vs. Density

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4.4.6 Spontaneous Ignition

The CRC Aviation Handbook lists two general types of spontaneous ignition: Autoignition and Hot Surface Ignition.

4.4.6.1 Autoignition Temperature (ASTM E659)

Autoignition Temperature (AIT), determined by ASTM E659, is the temperature at which fuel vapor will ignite in the absence of an ignition source. AIT values for typical hydrocarbon fuels are expected to fall between 200-260°C. The fuels tested in this study (Figure 8) all fell within the expected range.

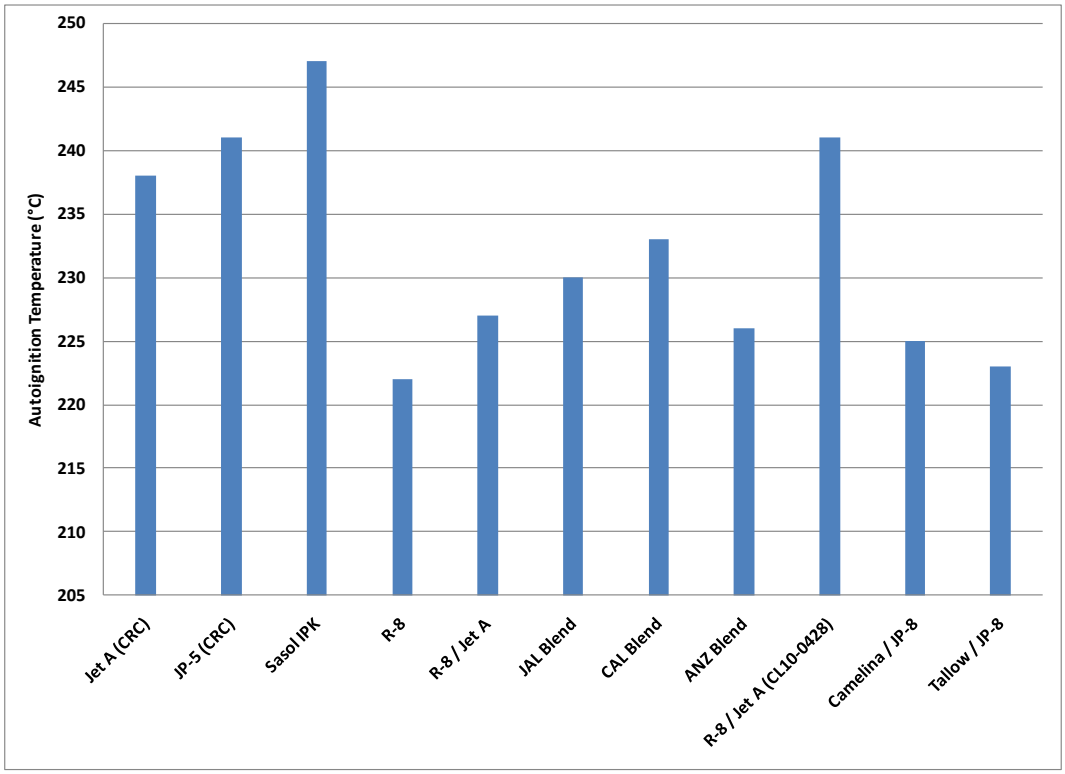

Figure 8. Autoignition Temperature

4.4.6.2 Hot Surface Ignition Temperature (FTM 791-6053)

The Hot Surface Ignition Temperature (HSIT) is measured according to Fed-Std-791 (6053). In the standard form of this test, the fuel is dripped onto a heated manifold at 1300°F. The purpose of this test is simply to determine whether the fuel burns or not at that temperature. There are no pass/fail criteria. SwRI runs a slightly modified procedure by attempting to bracket the actual ignition temperature. Expected values for HSIT are 800-1200°F. The fuels tested in this study (Figure 9) gave ignition temperatures between 1150-1275°F.

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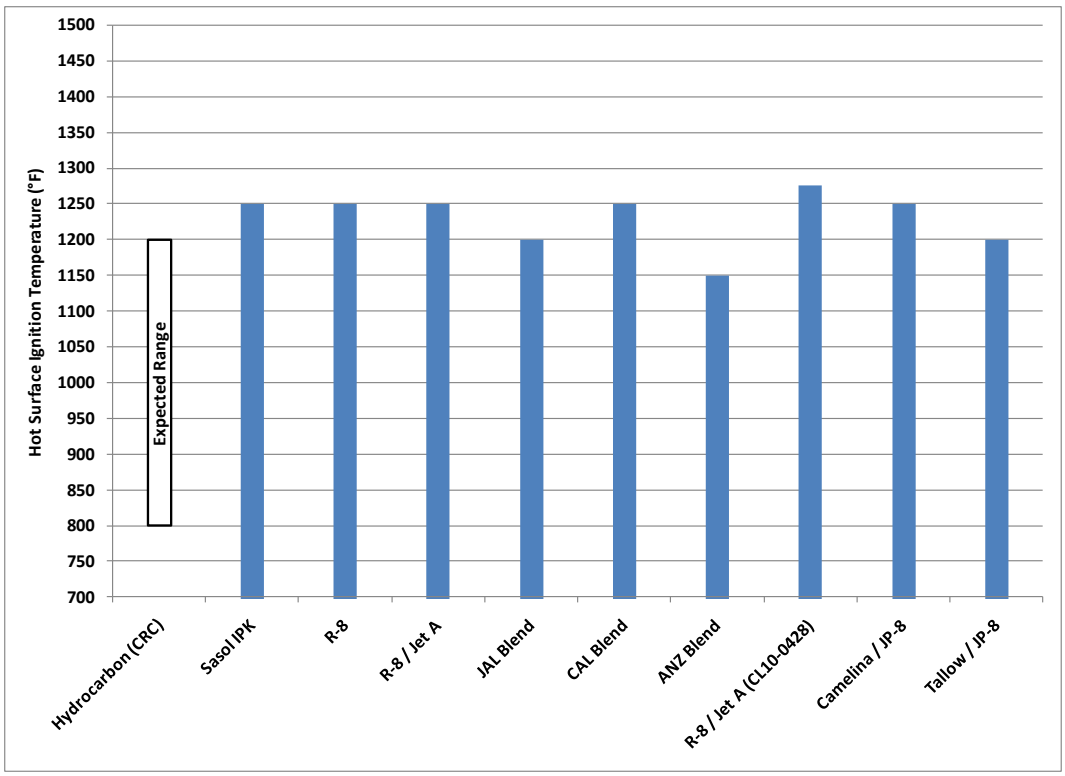

Figure 9. Hot Surface Ignition Temperature

4.4.7 Minimum Ignition Energy (ASTM E582)

This test measures the minimum amount of energy necessary to ignite a hydrocarbon fuel/air mixture. The energy is provided via a spark discharge and is expected to fall in the range of 0.2 to 1.0 mJ. The fuels in this study selected for this test fell within the expected range. In order to create the fuel/air mixture, the fuel had to be heated to get complete vaporization. A temperature of 100°C was the standard temperature employed. The only noted trouble was with R-8, which had to be heated slightly higher to achieve complete vaporization. This was also noted by the lab running the explosion limit tests. This appears to agree with the higher boiling point values seen in the D86 analysis. The R-8/Jet A blend (CL10-0428) prepared in 2010 continued to show vaporization issues.

4.4.8 Upper/Lower Explosion Limits (ASTM E681)

Like the minimum ignition energy test, testing for the upper/lower explosion limits require the fuel to be vaporized by heating. A temperature of 100°C was used here also with the noted exception of R-8, which had to be heated to 150°C. This trend repeated in 2010, with the R-8/Jet A blend giving very low UEL and LEL values. Of the fuels tested by this method, Figure 11, the lower explosion limits ranged from 0.4-0.5 vol% and the upper explosion limit ranged from 3.5-6.0 vol%. The nominally expected values were 0.6 and 4.7 vol%, respectively.

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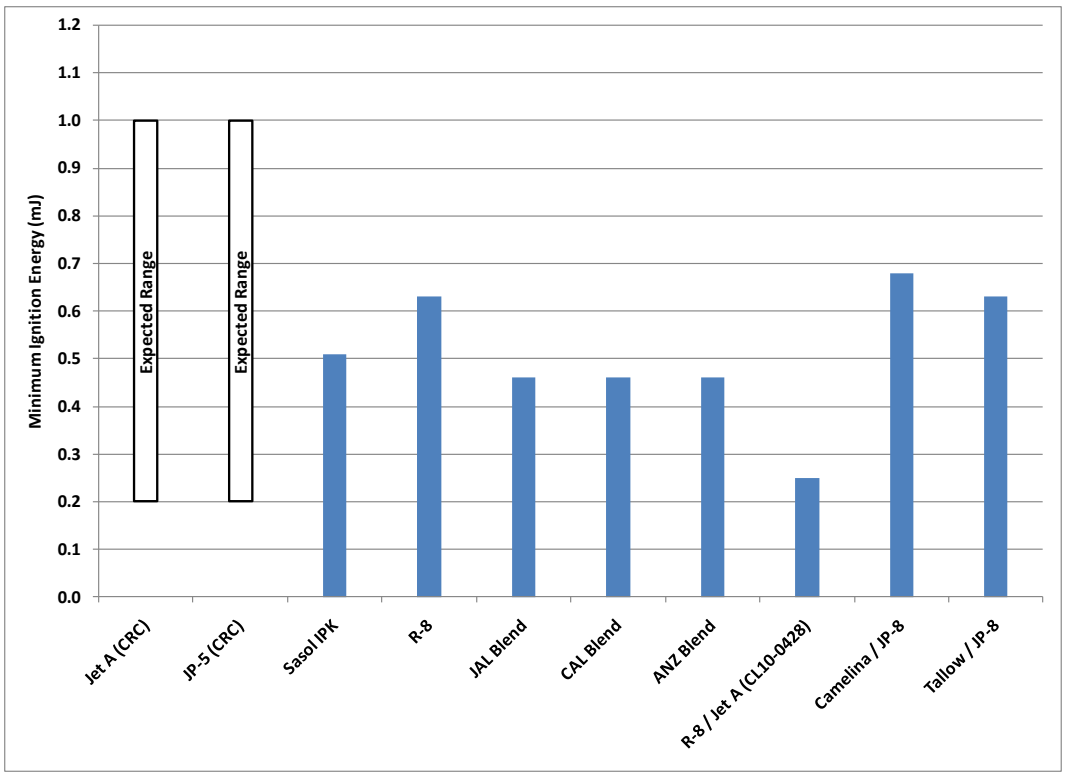

Figure 10. Minimum Ignition Energy

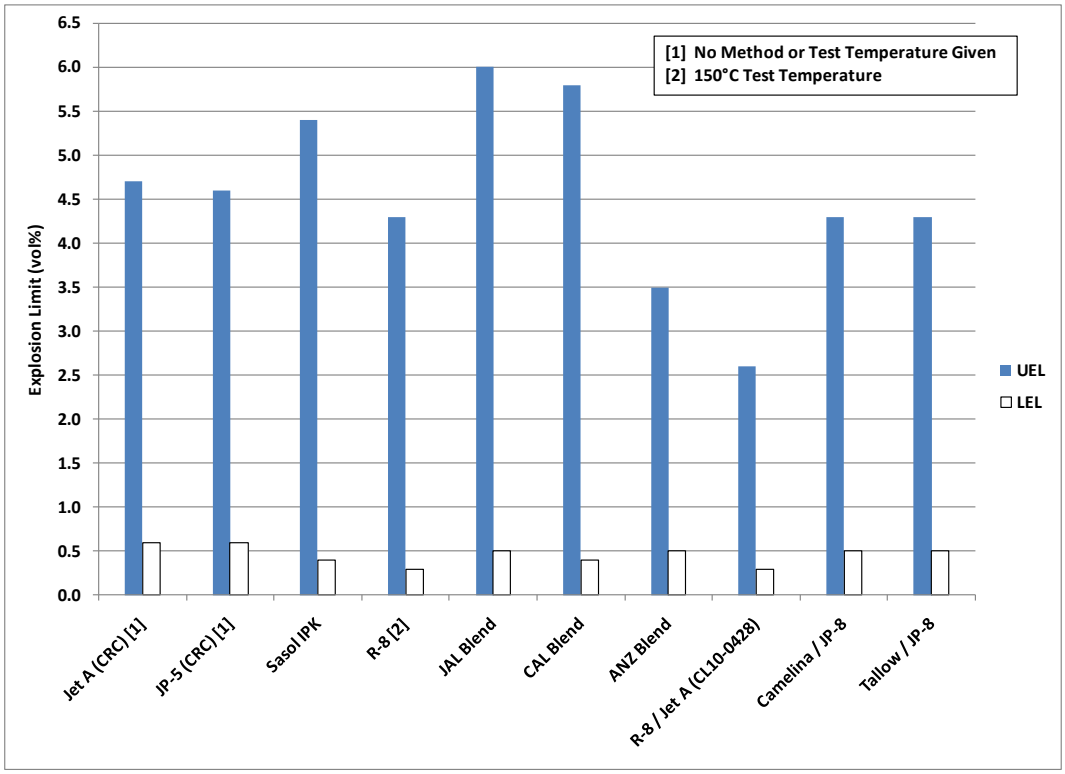

Figure 11. Explosion Limits

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4.4.9 Specific Heat Capacity (E2716)

The reversing heat capacity results are shown in Table 3 and plotted in Figure 12. The slopes of these curves are similar to those found by Boeing although we still see a slight negative bias in our data relative to theirs. There are many factors that can affect these results so reproducibility values in the range of 5-10% would not be unexpected. Like many other measurements, the values for the specific heat capacity of hydrocarbon-based fuels are going to vary in a narrow range. Gross changes in composition, like aromatic content or iso/normal paraffin ratios, would likely account for the most significant differences.

Table 3. Reversing Heat Capacity

SwRI Sample ID	Reversing Heat Capacity (kJ/kg.K)					Equation
	-30°C	0°C	50°C	100°C	150°C	
CL10-0429 (Jet A)	1.745	1.860	2.051	2.242	2.434	Cp = 0.0038*T + 1.8595
CL09-0268 (Sasol IPK)	1.860	1.989	2.205	2.420	2.636	Cp = 0.0043*T + 1.9893
CL09-0324 (R-8)	1.808	1.924	2.118	2.312	2.505	Cp = 0.0039*T + 1.9243
CL09-0325 (R-8/Jet A)	1.804	1.915	2.099	2.284	2.468	Cp = 0.0037*T + 1.9145
CL09-0636 (R-8x)	1.860	1.964	2.136	2.309	2.482	Cp = 0.0035*T + 1.9637
CL09-0501 (JAL)	1.697	1.808	1.992	2.177	2.361	Cp = 0.0037*T + 1.8076
CL09-0502 (CAL)	1.840	1.947	2.125	2.303	2.481	Cp = 0.0036*T + 1.9467
CL09-0503 (ANZ)	1.845	1.953	2.132	2.311	2.490	Cp = 0.0036*T + 1.9526
CL10-0327 (Camelina/JP-8)	1.800	1.907	2.084	2.262	2.439	Cp = 0.0035*T + 1.9068
CL10-0428 (R-8/Jet A)	1.797	1.905	2.086	2.267	2.448	Cp = 0.0036*T + 1.9051
CL10-0932 (Tallow/JP-8)	1.774	1.879	2.053	2.228	2.403	Cp = 0.0035*T + 1.8786
CL10-0326 (R-8)	1.822	1.928	2.104	2.281	2.458	Cp = 0.0035*T + 1.9276

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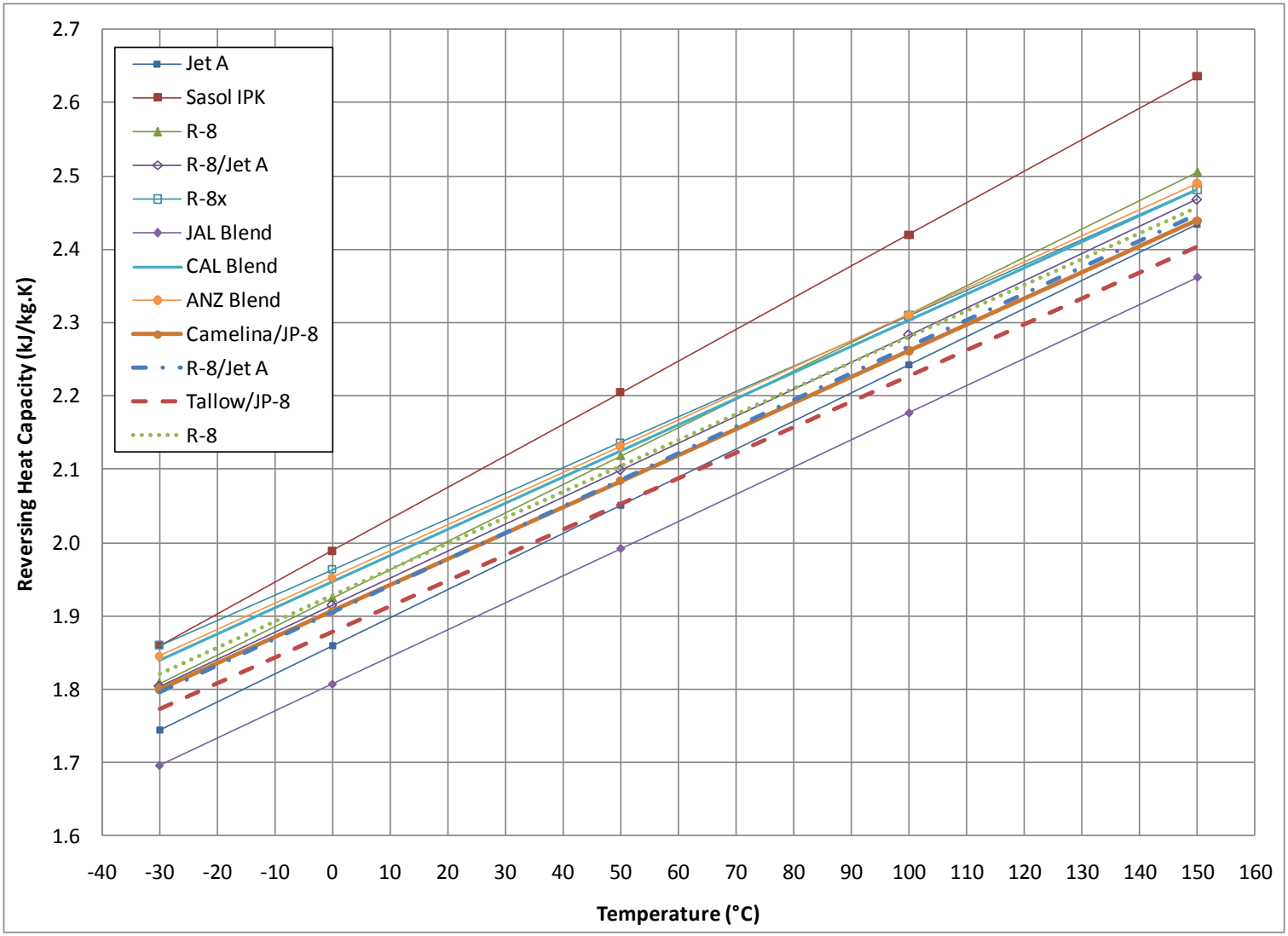

Figure 12. Reversing Heat Capacity

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4.4.10 Thermal Conductivity (Modified Transient Plane Source)

Based on data reported by the CRC Aviation Handbook and NIST[2], the expected thermal conductivity values for a typical aviation fuel might be expected to fall in the range of 0.9-0.14 W/m.K. Thermal conductivities calculated from TCi effusivity are shown in Figure 13. These data have been linearized for readability. In reality, the data is quite noisy. The change in thermal conductivity as a function of temperature is very small over this range and it appears that we are operating near the limit of resolution for this instrument. The CRC data shown in the figure was measured by the hot-wire technique. This difference between the two methods was not unexpected. As seen in some other tests, the Camelina/JP-8 exhibits some odd behavior relative to the other samples and the Sasol IPK is clearly distinguishable. The R-8 blends also appear to fall half-way between the neat R-8 and Jet A. Similar to specific heat capacity, it's likely that most hydrocarbon-based fuels are going to fall in a very narrow range as do these thermal conductivity values. Since these properties are primarily going to affect cooling capacity, additional input is needed from the OEMs to establish minimum criteria.

4.4.11 Surface Tension (D1331A)

From a practical application standpoint, surface tension is primarily affected by temperature and the presence of surfactants. An increase in temperature or the addition of surfactants generally causes a decrease in the surface tension of the fuel. Surface tension implies that the fuel is in direct contact with air. From a performance standpoint, the surface tension can affect fuel atomization.

For selected fuels in this study, the surface tension as a function of temperature is shown in Figure 14 and is in generally good agreement with the CRC Aviation Handbook values. From experience, the surface tension value can change dramatically (5 units or more) depending on the additives present. Clay treating can also cause a significant increase in surface tension. The Sasol IPK clearly stands out from the others. Its lower value is likely related to its isomerized composition. The Camelina/JP-8 exhibited a weaker response to temperature than the other fuels. Other unexpected results on the neat Camelina, such as boiling point distribution and vapor pressure, suggest that the chemical composition of the Camelina may be different than the other fuels.

[2] Data provided by AFRL but withheld from this report

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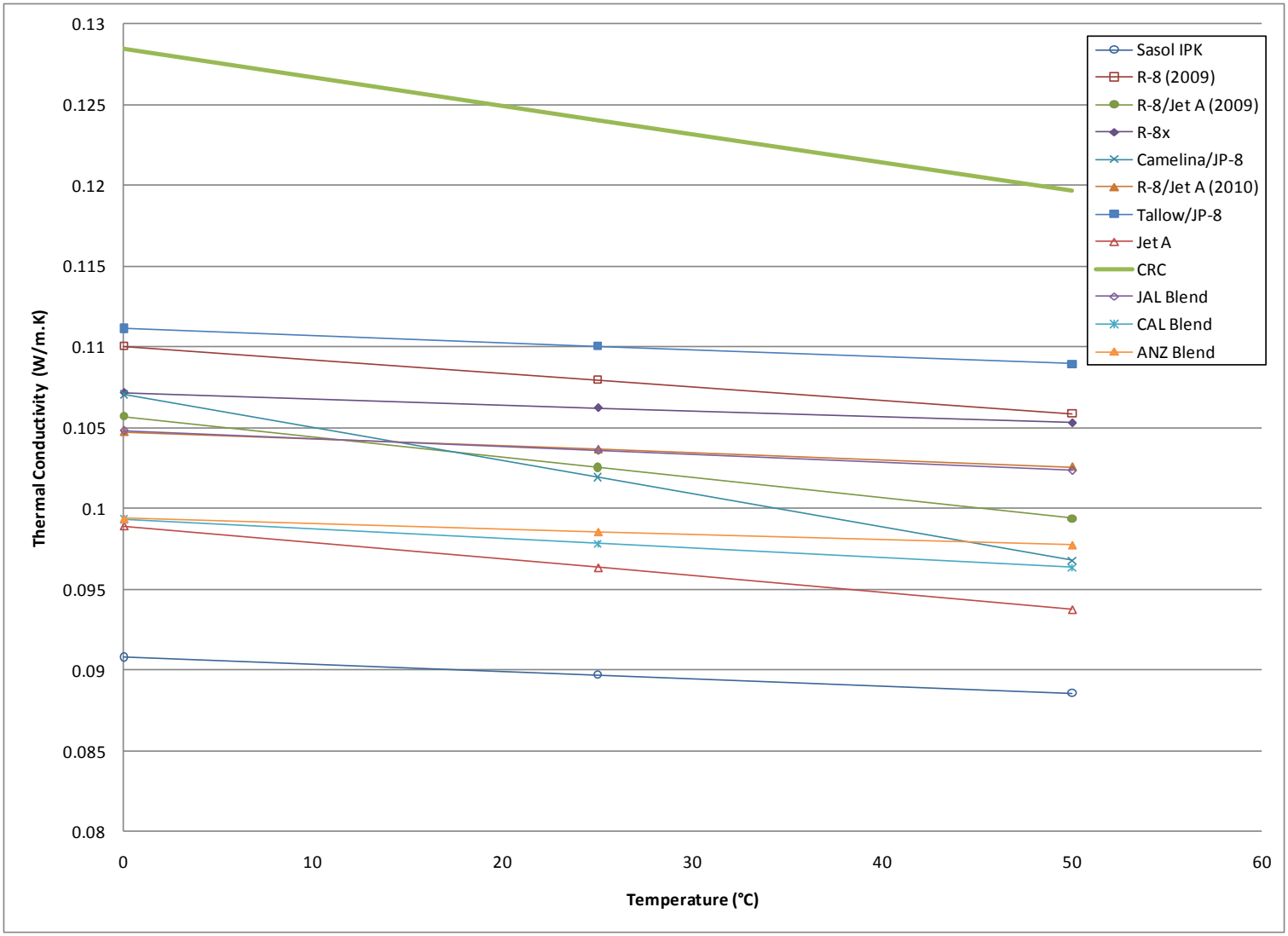

Figure 13. Thermal Conductivity

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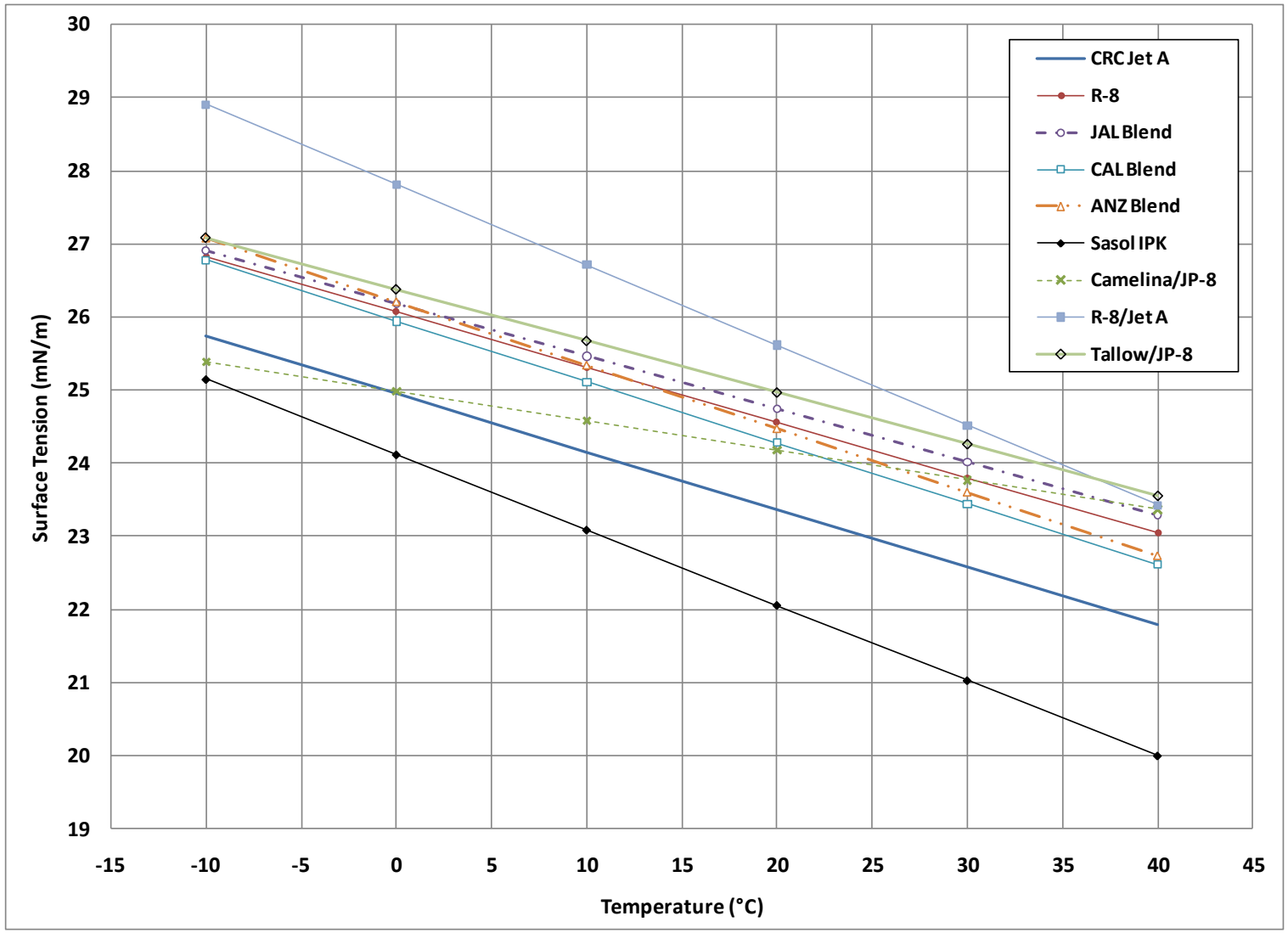

Figure 14. Surface Tension (D1331A) vs. Temperature

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4.4.12 BOCLE (D5001) vs. CI/LI Concentration (DCI-4A)

A standard BOCLE test of neat fuel provides an indication of the inherent lubricity of the fuel. Equally important is to determine the response of a unadditized fuel to the addition of a standard lubricity improver (DCI-4A). Prior to testing, the selected fuels are clay-treated to remove all additives. The fuels are then re-additized and their lubricity re-evaluated. The general finding is that most fuels respond immediately to low dosages of additive but quickly plateau at higher levels. Selected fuels are shown in Figure 15.

4.4.13 Water Content (D6304) vs. Temperature

Aviation fuels, like Jet A, tend to be relatively dry due to their saturated hydrocarbon composition. For a typical aviation fuel, temperature is the primary factor that affects water content; additives and contaminants may also play a role. The distinction between "free" and "dissolved" water is subtle. Free water tends to fall out quickly while dissolved water is a function of the fuel temperature (and other factors such as fuel composition). This test seeks to find the saturation limit of water in a given fuel at a given temperature. The Karl Fischer method utilized in this procedure measures total water content which should consist of only dissolved water following a long period of equilibration. Equilibrium is defined as the point at which the vapor space above the fuel is saturated with water. Without a direct means of measuring the water content of the vapor space, long equilibration times are used to ensure complete saturation.

The results for selected fuels are shown in Figure 16.

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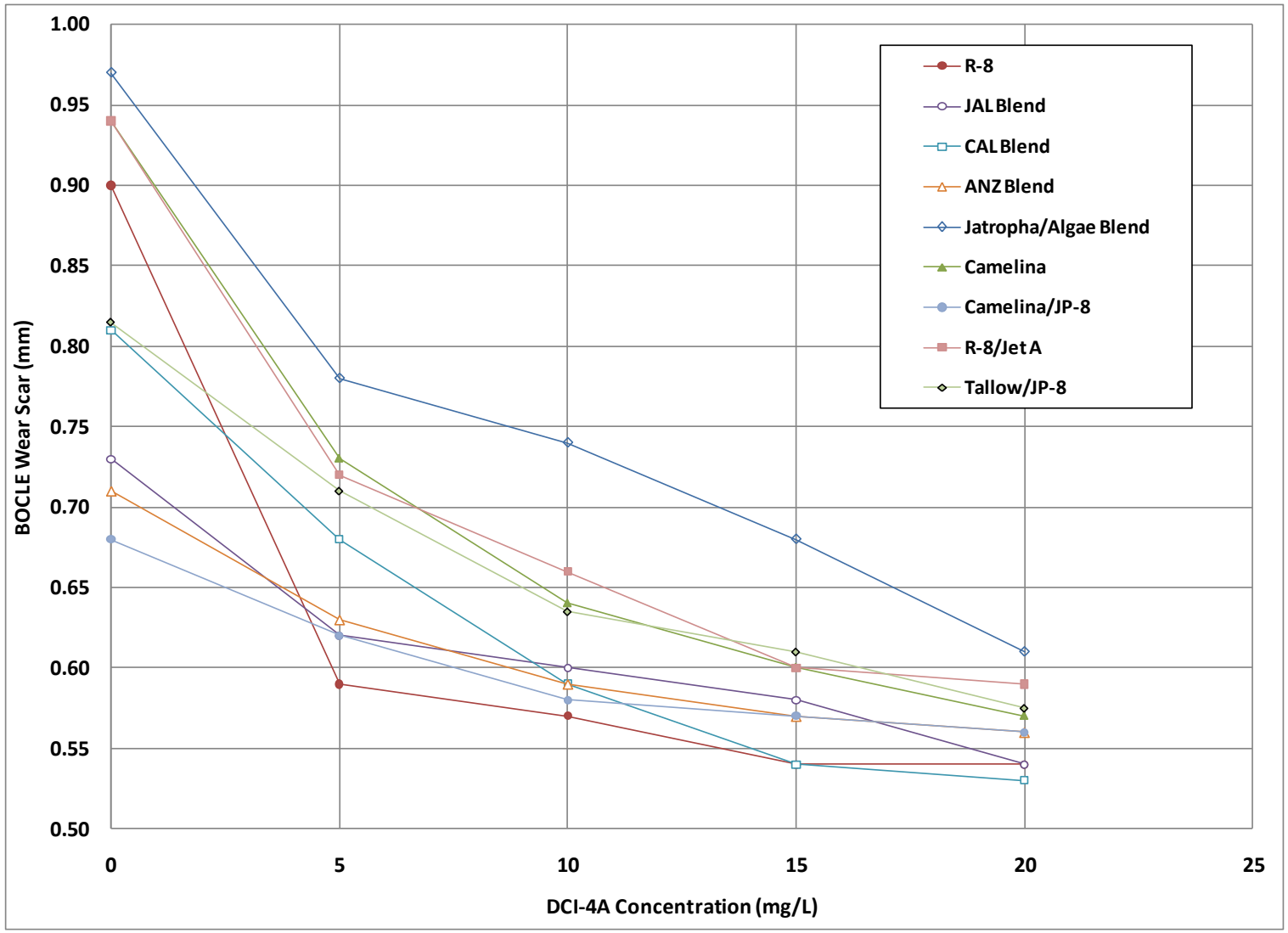

Figure 15. BOCLE (D5001) vs. CI/LI Concentration (DCI-4A)

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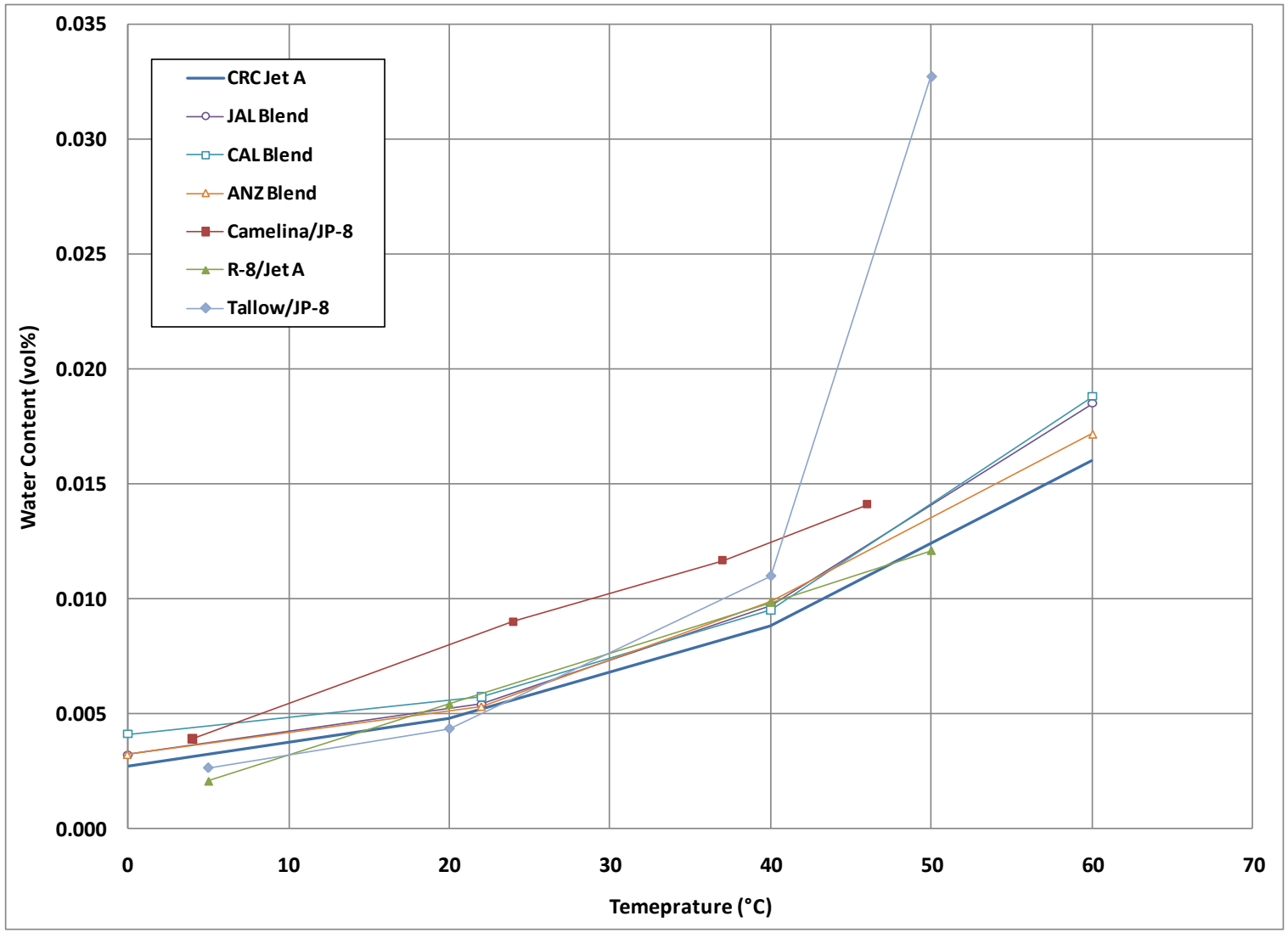

Figure 16. Water Content (D6304) vs. Temperature

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4.4.14 Kinematic Viscosity (D445)

Kinematic viscosity data for selected fuels are shown in Figure 17. The data shows good agreement to the CRC Aviation Handbook Jet A data. As with many other properties, the values for the Sasol IPK lie at the extremes of the data set.

4.4.15 Electrical Conductivity (D2624) vs. SDA Concentration (Stadis 450)

Understanding how a fuel responds to the addition of static dissipator additive (SDA) is critical to prevent over or under-additizing in the field. Procedurally similar to the lubricity evaluation, the fuel is first clay-treated and then dosed with varying amount of Stadis 450. The electrical conductivity is then measured at room temperature using a hand-held meter. A comparison of several fuels is shown in Figure 18.

4.4.16 Electrical Conductivity vs. Temperature

Electrical conductivity as a function of temperature is shown in Figure 19. This test is conducted by chilling a fuel sample down in a dry ice/alcohol bath to below -40°C and then allowing it to warm slowly to room temperature while periodically measuring the electrical conductivity with a handheld meter. Once at room temperature, the fuel is then warmed slowly with periodic measurements as before. Although it's possible to collect data in this manner, better temperature control and a fixed probe would likely yield more reproducible results. The Tallow/JP-8 blend gave unusually high values at elevated temperatures for reasons currently unknown. Values of this magnitude were reproduced several times.

4.4.17 EPA Testing

The complete reports for the EPA testing for carbonyls, alcohols, esters, and phenols are provided in the following Appendices:

- Camelina (CL10-0278) – Appendix K
- Camelina/JP-8 (CL10-0327) – Appendix K
- R-8 (CL10-0326) – Appendix K
- R-8/Jet A (CL10-0428) – Appendix K
- Tallow/JP-8 (CL10-0932) – Appendix L

For each sample, a report is provided showing the target compounds with those in bold indicating that they were present above the detection limit. Also provided is a table of compounds that were tentatively identified by the mass spectrometer. None of the identified compounds are remarkable as they could just as likely be found in a typical aviation fuel.

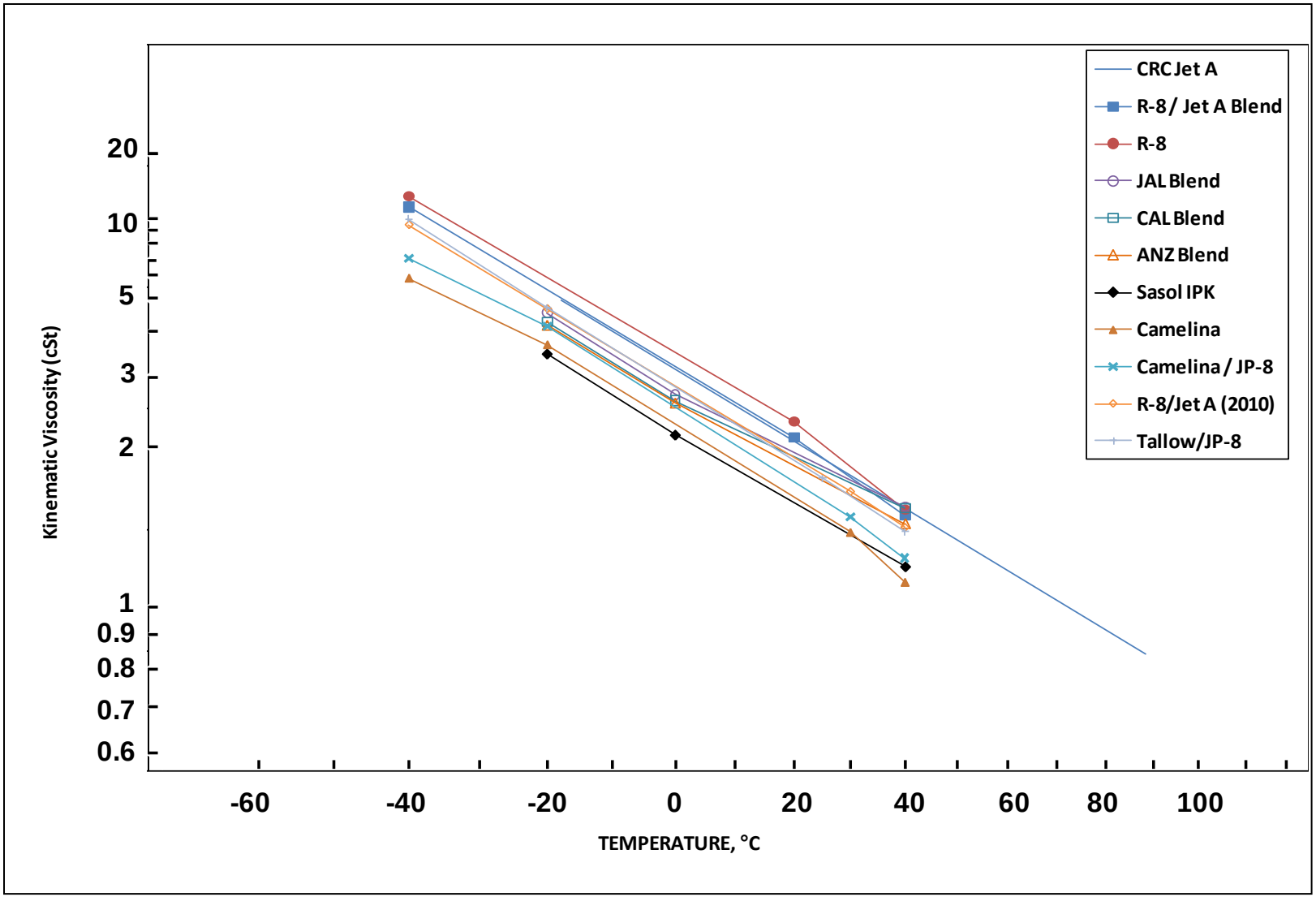

Figure 17. Kinematic Viscosity (D445)

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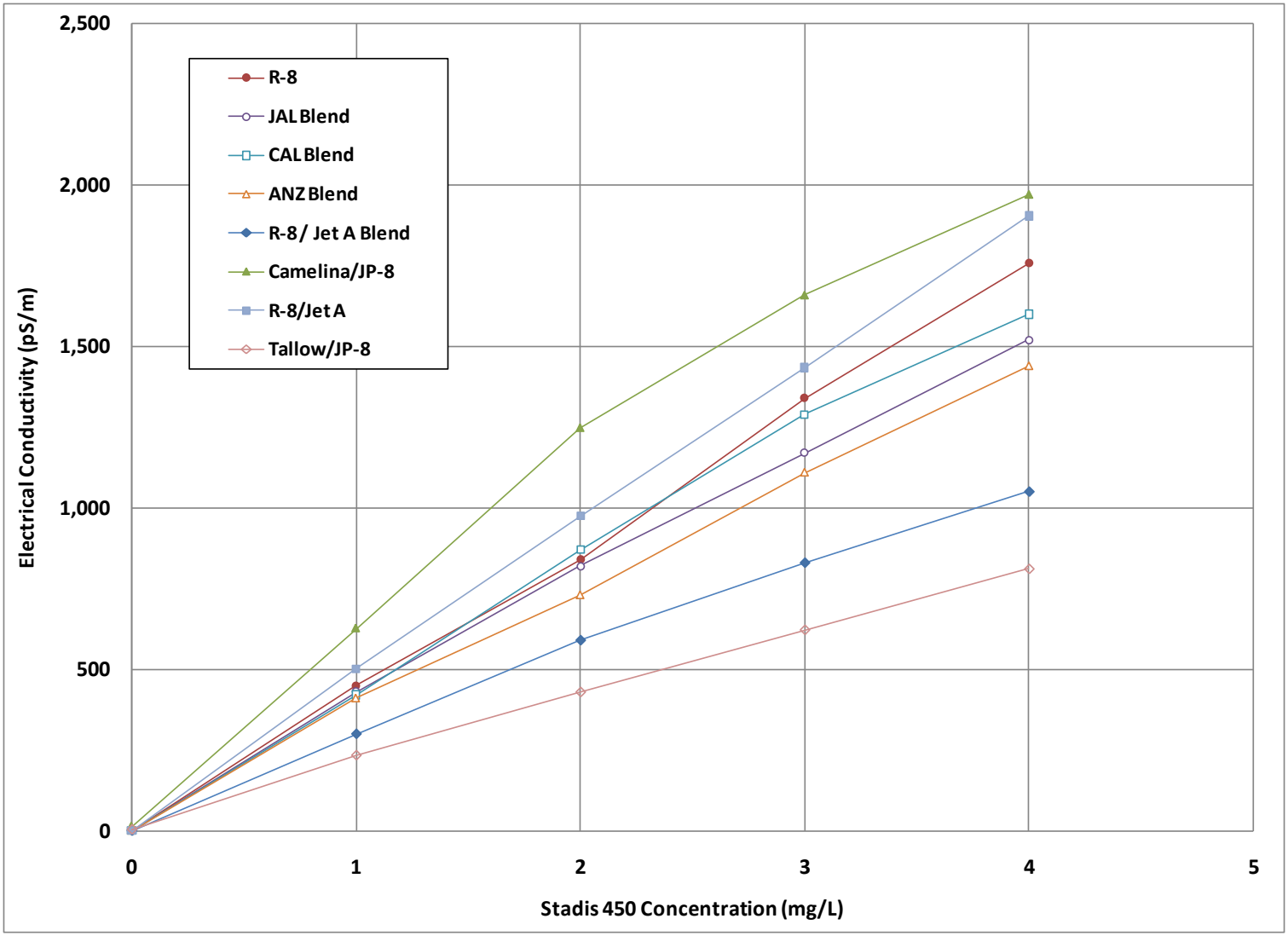

Figure 18. Electrical Conductivity (D2624) vs. SDA Concentration

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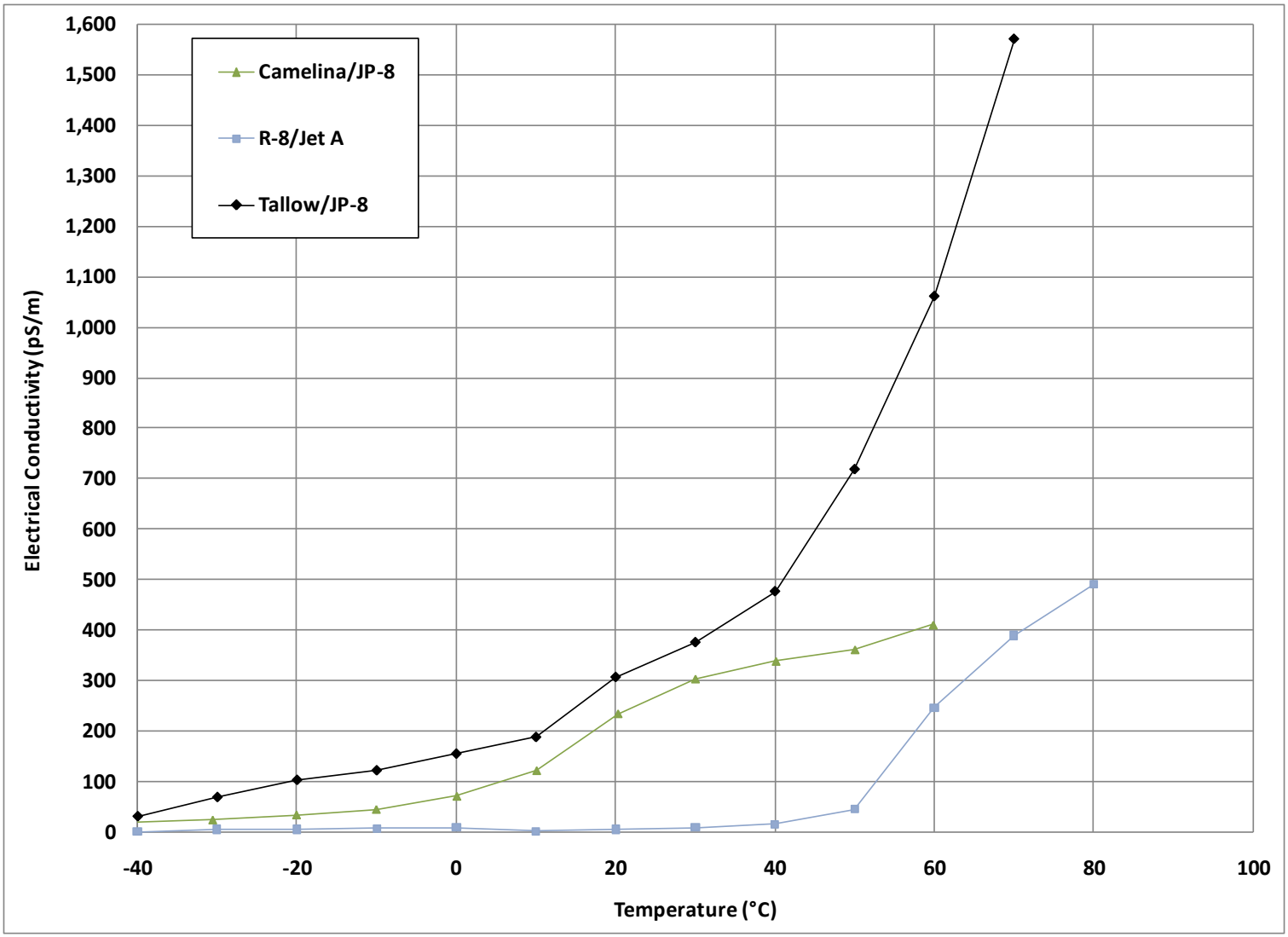

Figure 19. Electrical Conductivity (D2624) vs. Temperature

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4.4.18 Elastomer Compatibility

The complete results for each fuel tested by this method are included with their respective data sets in the appendices. Some comparative results are shown in Figure 20. In this figure, we use tensile load although this would be approximately proportional to tensile strength. Since no hard limits exist for tensile load/strength and volume change, the data is primarily qualitative. For tensile load/strength, the data is compared to a baseline run consisting of an unsoaked o-ring. What does appear significant is the effect of the R-8 on all three elastomers. This is the only neat fuel in the set and contains no aromatics. The relationship between increased aromatic content and increased volume swell (especially with nitrile) has been well-documented by others[5]. In this case, the 50/50 blends in the study all contain approximately 10% aromatics and exhibit similar behavior. The R-8, having no aromatics, shows reduced swelling or even shrinkage relative to the initial measurement. This effect could possibly lead to o-ring failure and leaks in the system. R-8 also imparts some minor loss of tensile load/strength in Viton and all fuels seem to have a minor effect on the fluorosilicone tensile load/strength relative to the unsoaked o-ring.

With respect to volume swell, the general impact on materials in this study follows the trend:

Fluorosilicone > Nitrile > Viton

In other independent studies, the nitrile was shown to swell more than the fluorosilicone. One problem with this testing is the lack of standardization in material selection. The o-ring composition and manufacturing variables will vary by manufacturer and even lot-to-lot within the same product line. All of this testing to date has been accomplished with o-rings from a single lot of each material. How these o-rings compare to the materials used by other labs performing this test is difficult to say.

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5.0 Conclusions

Overall, the testing performed to date provides strong evidence that blends composed of 50% synthetic fuel (FT SPK and HRJ SPK) and 50% petroleum-based fuel will be more than adequate as drop-in replacements for current petroleum-based fuels.

Although most of the fuels studied to date (particularly the 50/50 blends) would likely meet a standard jet fuel specification, each of the synthetic fuels in this study exhibit their own unique behavior. These differences seem related to the unique characteristics imparted on the fuel by the various feedstocks. Certainly, additional research seems necessary to determine why these characteristics are transferred to the fuel and not removed by the refining process. This further reinforces the need for fit-for-purpose testing to identify those unusual characteristics and to ensure that they are not significantly outside our current experience with petroleum-derived jet fuels.

For most of the synthetic fuels studied in this effort, the overriding differences probably stem from the lack of aromatics. This would likely affect several properties such as material compatibility (elastomer swelling/shrinkage), tank gauging (density), and additive compatibility (solubility). However, it's likely that these are all minor issues that could be resolved and would not be a hindrance to the use of this fuel.

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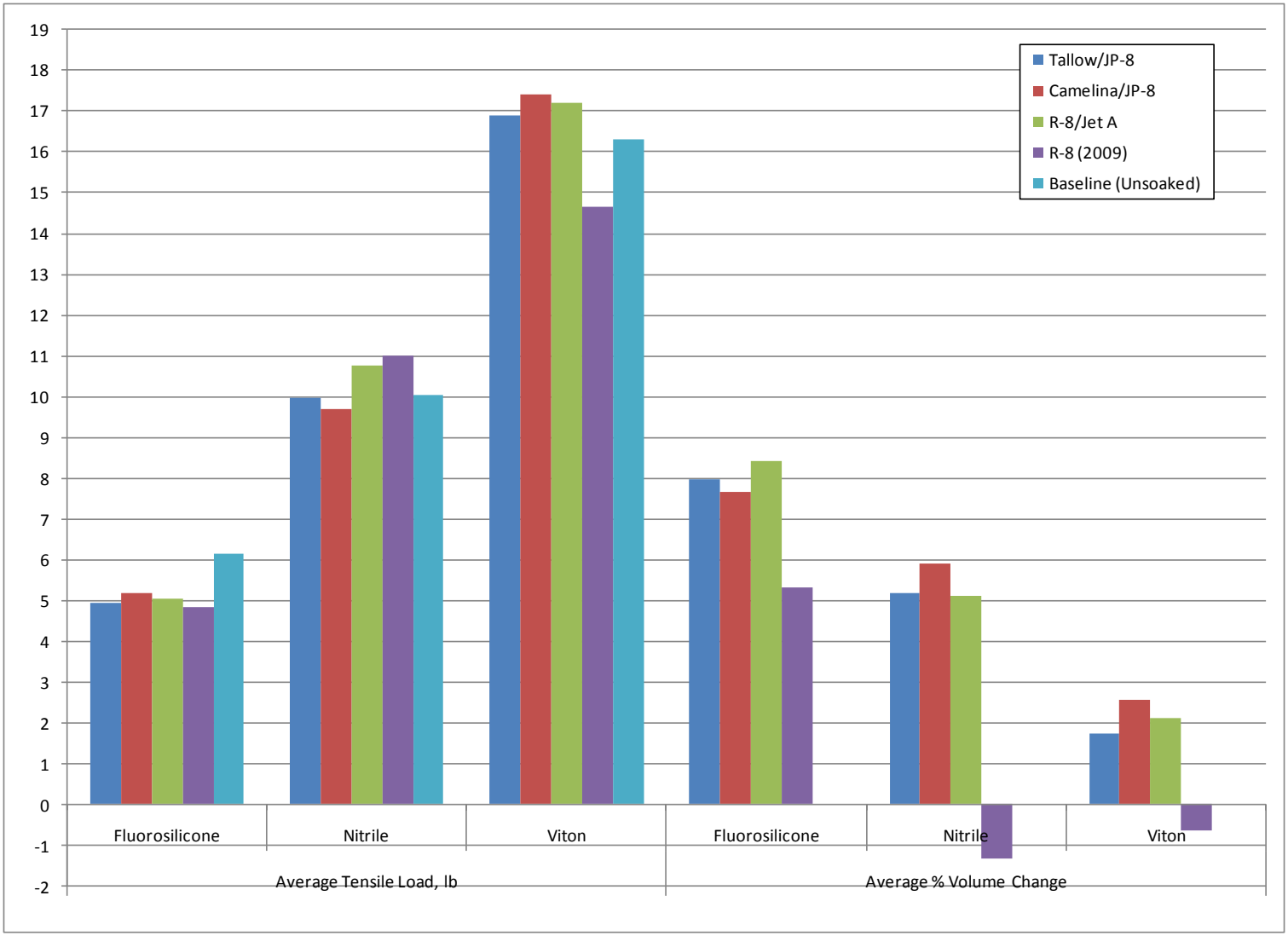

Figure 20. Elastomer Compatibility

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Due to its highly isomerized nature, Sasol IPK is one of the more distinct fuels tested to date. Although some of its fuel properties tend to lie at the extremes of what might be considered a typical aviation fuel, none of the differences appear excessive relative to other HRJ/SPK.

The testing of R-8 done to date confirms that it has every characteristic of a suitable HRJ SPK and compares favorably to other types of SPKs. Based on these favorable results, complete fit-for-purpose testing on an R-8/Jet A blend was recommended. This would provide the ASTM HRJ SPK task force with the information it needs to complete the approval process and assuage the fears of waste oils (FOG) as a potential feedstock source. Subsequent testing of an R-8/Jet A blend continued to show favorable results. Two particular results stood out from the testing.

First, two independent labs – one that performs the UEL/LEL testing and one that performs the minimum ignition energy testing – each observed that the fuel did not reach complete vaporization at 100°C. This had also been observed in 2009 with the neat R-8. All other fuels tested at 100°C showed no signs of condensation. This doesn't appear to affect combustion-related properties such as heat of combustion and IQT but further investigation may be warranted.

Second, some additive separation (FSII and part of the additive cocktail) was initially seen when added to R-8/Jet A at the 4X treat rate. A subsequent re-blending of the sample showed no separation. Although this may be attributable to insufficient blending, it demonstrated the need to blend thoroughly. Splash blending should certainly be avoided.

The work conducted on R-8x, an HRJ SPK of halophyte origin, was preliminary due to limited availability of the fuel. Although there were a few issues in testing, namely thermal stability, this is likely attributable to the finishing process or handling of the sample. In all other regards, it proves that it is feasible to produce an HRJ SPK from organic fats and oils regardless of the source.

Having been demonstrated to be flight worthy, the Boeing Flight Fuels have already achieved a high level of success. These fuels, all based on biomass sources, showed no outward signs of unusual behavior.

The neat camelina fuel did exhibit some unusual properties relative to the other fuels. The predominant differences were its low density, low viscosity, low boiling point distribution, and high vapor pressure. However, as a Camelina/JP-8 blend, many of these characteristics were suppressed and the fuel disappeared among the other HRJ SPK blends.

The most unusual characteristic of the Tallow/JP-8 blend was its affinity for water especially at high temperature. This was verified several times. In addition, similar to the R-8 / Jet A, the Tallow / JP-8 showed signs of additive separation when tested at the 4X treat rate. Like the R-8 blend, the FSII and the additive cocktail seemed to have the most problems staying in solution. A re-blend of this sample showed no improvement. Further investigation is likely necessary.

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6.0 Recommendations

The need to expand aviation fuel testing to include fit-for-purpose tests has identified several shortcomings in the methods currently suggested. The problems include undocumented procedures, non-standard practices, impractical procedures, and limited availability of labs to perform the procedures. Below, we will outline some issues that have been encountered and some recommendations for future development.

6.1 Comparative Data

In hind-sight, one major shortcoming was the lack of comparative Jet A data. Throughout this entire effort, no one single Jet A was subjected to all of the fit-for-purpose tests. Much too late, we found that the historical data that exists may not be representative or is too general for practical use (multiple fuel types represented by one curve). For many of the new methods that were investigated, at least one Jet A was typically run for comparison. For the common specification tests, general experience may serve as a guide. Nevertheless, care should be taken in the future to have at least one petroleum-based Jet A for comparison.

Additionally, many of the new methods being utilized have no min/max or pass/fail criteria. In some cases, the data that does exist is old or was acquired by questionable means. This makes it difficult to determine whether the data for candidate fuels falls within a reasonable range. One suggestion would be to seek input from the OEMs to better define their tolerance levels for certain properties based on the operation of their equipment.

6.2 Bulk Modulus

In this effort, the isothermal tangent bulk modulus of the fuels was determined by ASTM D6793 which uses classical P-V-T measurements. From the literature, the preferred approach is to determine isentropic (a.k.a. adiabatic) bulk modulus from speed-of-sound measurements. Based on some preliminary speed-of-sound measurements performed at SwRI we have concluded that our isothermal bulk modulus values are biased high. Despite on-going attempts to isolate and correct the problem we have been generally unsuccessful.

Since isentropic bulk modulus is preferred, future samples should be evaluated that way. Samples would need to be evaluated as a function of both temperature and pressure. To our knowledge, no commercial solutions exist for this purpose. To that end, SwRI currently has a project underway with the U.S. Army to build and deliver a bulk modulus rig based on speed of sound that can operate up to 100°C and 30,000 psi. The primary application for the Army is the high-pressure common rail fuel system but this should certainly meet aviation fuel requirements as well. SwRI intends to duplicate this test rig for its own in-house testing. A study should be performed on a wide range of aviation fuels to form a baseline for future comparison.

6.3 Dielectric Constant

To measure dielectric constant, SwRI is currently using a k-cell on loan from Goodrich Sensors and Integrated Systems. This k-cell is one of only a few in existence. An alternative cell is needed to replace these aging k-cells. Goodrich is currently working toward a new design for a k-cell that they can produce and sell. When that design is finalized, SwRI intends to acquire one to support its aviation fuel testing. While we still have the Goodrich k-cell in-hand, a

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comparative study between the two cells should be performed. In addition, a standardized procedure needs to be develop for measuring dielectric constants of aviation fuel.

6.4 Fuel/Water Separation

Although ASTM D4054 mandates the use of API/EI 1581, this test is generally impractical for pre-production runs of candidate fuels. In addition, there are only a few labs in the world that run this test. Therefore, an alternative method is needed to pre-screen candidate fuels for early signs of fuel/water separation issues. In this effort, we proposed to use SAE J1488 as an alternative method which requires approximately 200-L of fuel (previous tests required 50-L but the method has been recently updated). The goal of this method is to determine the water removal efficiency of a given test filter. However, by standardizing on a "known-good" filter (the M1A1 filter in this case), we can also test candidate fuels. There are several aspects of this test, such as water content, water measurement, and overall procedure that could be modified to make it more similar to the API/EI test. This investigation could form the basis of a study to create a more affordable and practical alternative

6.5 Material Compatibility

Material compatibility poses a significant challenge. The high cost of testing and limited availability of specific materials can make it difficult to perform on each new candidate fuel. Although various groups have performed this testing, a common problem seems to be the lack of standardization with regard to materials. While most everyone will include nitrile, viton, and fluorosilicone elastomers, the source of these materials varies by lab. Since the composition and manufacturing process of the elastomers will vary between manufacturers and even lot-to-lot, this creates an issue with generating comparative numbers from lab-to-lab. Some consideration should be given to this and perhaps find a means to standardize the materials. For instance, o-ring testing seems to be a common practice. Perhaps a common source of o-ring can be identified and a procedure written specifically around testing that material. Material compatibility under dynamic conditions should also be further investigated. SwRI's Dynamic Seal Tester allows o-rings to be tested in an environment that simulates axial stress and high temperature.

The effect of switch-loading fuels is also very important and can apply to both static and dynamic material compatibility tests. This will become especially critical in the field where fuels of varying composition may be encountered once synthetic fuels become more widely available. The lack of aromatics in synthetic fuels and even the low levels of aromatics in 50/50 blends have been shown to effect elastomer seals upon switching from a petroleum-derived fuel source (and vice versa). The effect of switch-loading should be incorporated as an element of the material compatibility tests.

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7.0 References

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2. Kinder, J. D. and Rahmes, T., Evaluation of Bio-Derived Synthetic paraffinic Kerosenes (Bio-SPK), The Boeing Company, 2009.
3. Handbook of Aviation Fuel Properties, CRC Report No. 635, 3rd Edition, Coordinating Research Council, Alpharetta, GA, 2004.
4. CRC World Fuel Sampling Program, CRC Report No. 647, Coordinating Research Council, Alpharetta, GA, 2006.
5. P.A. Muzzell, B. J. McKay, E. R. Sattler, R. A. Alvarez, and L. L. Stavinoha, "The Effect of Switch-Loading Fuels on Fuel-Wetted Elastomers," SAE Paper 2007-01-1453, presented at the SAE 2007 World Congress, Detroit, April 2007.

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8.0 Acronyms

Acronym	Description
µm	micrometer
AA	atomic absorption
ANZ	Air New Zealand
BOCLE	ball-on-cylinder lubricity evaluator
BTU	British Thermal Unit
°C	Celsius
CAL	Continental Airlines
CI/LI	Corrosion Inhibitor/Lubricity Improver
cSt	centistokes
DCN	derived cetane number
EPA	Environmental Protection Agency
°F	Fahrenheit
FFP	fit-for-purpose
FT	Fischer-Tropsch
FTM	Federal Test Method
g	gram
GTL	gas to liquid
HEFA	Hydroprocessed Esters and Fatty Acids
HFRR	high frequency reciprocating rig
HRJ	hydroprocessed renewable jet
HRJ8	50/50 blend of HRJ/Jet A containing JP-8 additives
Hz	hertz
ID	ignition delay
IPK	iso-paraffinic kerosene
IQT™	Ignition Quality Tester
JAL	Japan Airlines
JFTOT	Jet Fuel Thermal Oxidation Tester
K	Kelvin
kg	kilogram
kHz	kilohertz
kJ	kilojoule
kPa	kilopascal
L	liter
lb	pound
LEL	lower explosion limit
lpm	liters per minute
m	meter
mg	milligram
MJ	megajoule
mJ	millijoule
mL	milliliter
mm	millimeter
mN	millinewton
MPa	megapascal
ms	millisecond
NMR	nuclear magnetic resonance
ppb	part per billion

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Acronym	Description
ppm	part per million
psi(a or g)	pounds per square inch (absolute or gauge)
SAE	Society of Automotive Engineers
SDA	static dissipator additive
SPK	synthetic paraffinic kerosene
TWA WRE	time-weighted average water removal efficiency
UEL	upper explosion limit
W	watts

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Appendix A

Sasol IPK Data

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Table A-1. Results for Sasol FT-IPK

SwRI Sample Code			CL09-00268
Test	**Method**	**Units**	**Sasol FT-IPK (POSF5642)**
Surface tension	D1331A		
-10°C		mN/m	25.3
23°C		mN/m	21.3
40°C		mN/m	20.3
JFTOT Breakpoint	D3241BP		
Test Temperature		°C	>340
ASTM Code		rating	>2
Maximum Pressure Drop		mm Hg	0.1
JFTOT deposit thickness	D3241BP		
260°C		nm	16.21
280°C		nm	20.00
300°C		nm	23.67
320°C		nm	28.63
340°C		nm	34.40
Density	D4052		
0°C		g/mL	0.7719
15°C		g/mL	0.7609
40°C		g/mL	0.7422
60°C		g/mL	0.7276
80°C		g/mL	0.7121
Kinematic Viscosity	D445		
-20°C		cSt	3.44
0°C		cSt	2.14
40°C		cSt	1.17
100°C		cSt	0.62
Vapor Pressure	D6378		
0°C		psia	0.18
10°C		psia	0.22
20°C		psia	0.26
30°C		psia	0.30
40°C		psia	0.36
50°C		psia	0.45
60°C		psia	0.59
70°C		psia	0.80
80°C		psia	1.08
90°C		psia	1.49
100°C		psia	2.05
110°C		psia	2.79
120°C		psia	3.80
Pour Point	D5949	°C	<-79.2
Isothermal Tangent Bulk Modulus, 30°C	D6793		
0 psig		psig	182391
1000 psig		psig	192990
2000 psig		psig	203885
3000 psig		psig	215077
4000 psig		psig	226565
5000 psig		psig	238351
6000 psig		psig	250432
7000 psig		psig	262811
8000 psig		psig	275486

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Table A-1. Results for Sasol FT-IPK

SwRI Sample Code			CL09-00268
Test	**Method**	**Units**	**Sasol FT-IPK (POSF5642)**
9000 psig		psig	288458
10000 psig		psig	301726
Isothermal Tangent Bulk Modulus, 60°C	D6793		
0 psig		psig	148982
1000 psig		psig	160703
2000 psig		psig	172865
3000 psig		psig	185467
4000 psig		psig	198509
5000 psig		psig	211992
6000 psig		psig	225916
7000 psig		psig	240280
8000 psig		psig	255085
9000 psig		psig	270330
10000 psig		psig	286016
Elemental Analysis	D7111		
Al		ppm	<100ppb
Ba		ppm	<100ppb
Ca		ppm	<100ppb
Cr		ppm	<100ppb
Cu		ppm	<100ppb
Fe		ppm	<100ppb
Li		ppm	<100ppb
Pb		ppm	<100ppb
Mg		ppm	<100ppb
Mn		ppm	<100ppb
Mo		ppm	<100ppb
Ni		ppm	<100ppb
K		ppm	<1
Na		ppm	1.30
Si		ppm	<100ppb
Ag		ppm	<100ppb
Ti		ppm	<100ppb
V		ppm	<100ppb
Zn		ppm	<100ppb
Specific Heat Capacity	E2716	kJ/kg.K	Table 3
Minimum Ignition Energy	E582	mJ	0.51
Autoignition temperature	E659		
Hot Flame Autoignition Temperature		°C	247
Hot Flame Lag Time		seconds	19.0
Cool Flame Autoignition Temperature		°C	-
Cool Flame Lag Time		seconds	-
Barometric Pressure		mm Hg	741
Reaction Threshold Temperature		°C	217
Upper Explosion Limit (UEL), @100°C	E681	%	5.40
Lower Explosion Limit (LEL), @100°C	E681	%	0.40
Hot Surface Ignition Temperature	FTM 791-6053	°F	1250
Removal of Emulsified Water	SAE J1488	TWA WRE **	100% See Table A-2
Dielectric Constant (400Hz)	SwRI		
-36°C		--	2.10
-20°C		--	2.07

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Table A-1. Results for Sasol FT-IPK

SwRI Sample Code			CL09-00268
Test	**Method**	**Units**	**Sasol FT-IPK (POSF5642)**
2°C		--	2.05
37°C		--	2.01
50°C		--	1.99
60°C		--	1.99
72°C		--	1.97
78°C		--	1.97
Thermal Conductivity	SwRI		
0°C		W/m.K	0.0908
25°C		W/m.K	0.0897
50°C		W/m.K	0.0886
Ignition Quality Test (IQT)	D6890		
Ignition Delay, ID		ms	6.9
Derived Cetane Number, DCN		--	31.28
Cetane Number	D613	--	25.40

**** TWA WRE = Time Weighted Average Water Removal Efficiency**

Table A-2. SAE J1488 Results for Sasol FT-IPK (POSF5642)

Test Description	SAE J1488	**Test No**	# 1
Test Engineer	Gary Bessee	**Filter ID**	M1
Test Fluid	Sasol IPK (CL09-00268)	**Test Date**	7/15/2009
Vacuum / Pressure	Pressure	**Test Temperature, °C**	26.6
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	74.50

Fuel/Water Interfacial Tension (mN/m)	
Before	38.68
MSEP	
Before	99

Sample ID	Test Time (minutes)	Upstream (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from Test Filter (mL)
			Measured	Adjusted		
1	10	508.3	113.70	39	9.61	0
2	30	2820	139.70	65	10	52
3	50	2480	81.02	7	10.22	440
4	70	2260	49.46	0	11.1	320
5	90	2850	37.69	0	11.2	480
6	110	3270	31.47	0	11.39	570
7	130	3190	24.59	0	11.34	385
8	150	1800	63.79	0	11.39	380

Average Water Content, ppm	2397
Time Weighted Average Water Removal Efficiency (%)	100%
Total Water from Test Housing (mL)	2627
Water from Cleanup Filters (mL)	0

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Appendix B

R-8 Report

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EVALUATION OF R-8 HRJ SPK

FINAL REPORT
SwRI® Project No. 08-14406.04.001

Prepared for

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November 2010

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Executive Summary

Syntroleum® R-8 Hydroprocessed Renewable Jet (HRJ) Synthetic Paraffinic Kerosene (SPK) is a jet fuel blending material made from waste fats, oils and grease (commonly called FOG). While some of this raw material is being used in the production of biodiesel, much of it is too contaminated for those, typically, low tech processes. Syntroleum has devised a process suitable for industrial scaling that removes the impurities and prepares it for the hydroprocessing necessary to make HRJ SPK.

This program is a follow on to previous work ("*Research of Renewable IPK Alternative Jet Fuel*" SwRI Project No. 13283) where we explored some of the most critical properties of the neat material. That work was very satisfactory, showing R-8 to be fully compatible with similar properties to other synthetic paraffinic kerosines (SPK), both from Fischer-Tropsch (FT) and from hydroprocessed fats and oils (HRJ). Based on that work, SwRI recommended continuing on to a full analysis of R-8 as a blend stock.

The agreed upon program continued the work to cover finishing the Fit-for-Purpose (FFP) analysis of the neat material and to do selected blend studies with specification jet fuel. The results of this work showed that R-8 is entirely normal in comparison to SPKs as a class. Parts of the data are being shared with the industry by AFRL, the ultimate client, and in feedback there was a question of source purity. A short analysis of that issue was conducted and it showed it would not be possible to make HRJ SPK without sufficient purification.

Based on the cumulative work, R-8 shows every characteristic of a suitable HRJ SPK. The final proof will be doing the complete FFP evaluation of R-8 blended into fuel compliant with ASTM D7566 and/or MIL-STD-83133F. This evaluation should provide the needed animal/waste fat and oil data to fill in the needed data for the HRJ SPK Task Force and to lay to rest the issue of FOG as a source. SwRI therefore recommends moving forward with this project and doing the complete blend analysis.

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1.0 Objective

The object of this program is to finish the evaluation of the neat R-8 started in a previous program and to do selected tests with blends thereof. The data from this program will be used in support of the program to add synthetic paraffinic kerosine from hydroprocessed fats and oils (HRJ SPK) to ASTM D7566, the Standard Specification for Aviation Turbine Fuel Containing Synthetic Hydrocarbons.

2.0 Background

In the final report for Southwest Research Institute® Project No. 08.13283.01.001, *"Research of Renewable IPK Alternative Jet Fuel"* we stated that, overall, the R-8 looks like a very good SPK candidate, despite the anticipated poor lubricity. That was seen early in the previous test program, and we recommended moving forward with the complete analysis of the Fit-for-Purpose (FFP) properties of the R-8 and blends thereof. The aviation industry, in general has seen enough data on synthetic kerosines from hydroprocessed renewable feedstocks (HRJ SPK) to preliminarily assess that a test program similar to that done for the FT SPKs would be the next step for HRJ SPK like R-8. Rather than finish all of the FFP properties for the neat R-8 and then do the complete FFP series on the blended fuel the decision was made to do the former and a selected subset of the latter. The R-8 data will provide a valuable link into generating a collective approval for renewable kerosine blend stocks.

3.0 Samples

SwRI was provided with three drums of R-8 material for use in the testing program as part of the previous program (noted above). The two drums used for the pump testing were directed to a new pump test effort. There was sufficient R-8 available for the tests in this program.

The neat R-8 (Lot 1) was assigned SwRI sample number CL09-00324. SwRI prepared a 50/50 blend of the R-8 with a Jet A, meeting the ASTM D1655 specification. The R-8 / Jet A blend was assigned SwRI sample number CL09-00325.

4.0 Analysis

(The R-8 test results can be found in Table B1-1.)

4.1 R-8 as a HRJ SPK

ASTM is pushing forward on the development of a specification allowance for aviation kerosine derived from hydroprocessed fats and oils (HRJ SPK). The data generated at SwRI on the R-8 is a key component of the data analysis going into the research report being put together by the HRJ Task Force under the ASTM D.02.J.06 Emerging Turbine Fuels Section of the Aviation Fuel Subcommittee, chaired by George Wilson (SwRI). The preliminary draft of this report was passed to the OEM community in the first week of December 2009.

During the recent ASTM meeting, December 7-11, 2009, a question was raised about the source of the potential fats and oils. The questioner wanted assurance that this process would not allow the use of 'dirty' fats and oils like those from grease traps or sewage skimmers. It was pointed out that one of the subject HRJ SPKs (R-8, unnamed) was made from yellow grease but that did not

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seem to equate to his mind. We believe that the level of purity required by the D7566 SPK requirements would make the ultimate source immaterial. (However, we followed up on this issue and it will be discussed in the next section.) Additional discussion on the sourcing of the grease used for the R-8 process may be beneficial for the goal of getting the OEM approval for HRJ SPK. While R-8 is being used as an HRJ SPK example in the report, the fact that there are source questions argues in favor of moving on to full blend testing.

With the delivery of the preliminary research report to the OEMs the approval process for HRJ SPK has entered the critical stage. Based on the FT-SPK experience and additions thereto, we feel the chemistry work is well in hand. However, just as there was in the FT process, the OEMs may well require additional testing. The OEMs too have testing in the works that will be a key component to HRJ SPK. Each one has specific engine and component testing they need completed before they will approve the new category. They consider the existing flight test data as sign of customer interest and commitment but not specifically material to their issues.

Assuming all the participants delivered all the key laboratory data and the OEMs finish their work in reasonably short order, ASTM should be able to move the report and the revised wording for D7566 to ballot this year. With the ASTM consensus process it is likely the first pass will have negatives to resolve. Regardless, there is a reasonable chance that this specification will be modified by the end of 2010.

4.2 From Bad to Good – Turning Waste into Kerosine

We had been provided with a general background on the Syntroleum production of the R-8 and the fact that it consisted primarily of yellow grease. We requested, and UTC kindly provided, the production report on R-8 (from Subcontract: 07-S530-0042-06-C1). In fact, it proved that the R-8 starting material was a diverse mixture of what the waste industry calls FOG, for fats, oils and grease. Cleaning this material as a prelude to the hydrotreating process is a requirement. Quoting from the report: "Pretreatment of Fats, Oils and Greases (FOG) is required to reduce the solids contaminant load on the downstream HDO reactor. Contaminants include animal solids, rust particles, and solubilized metals. If not removed, these will deposit in the fixed bed reactors causing excessive pressure drop across the catalyst bed and catalyst activity decrease."

The FOG mixture is described in Table B-:

Table B-1. Make-up of FOG Blends

FOG Blend Components	Component Mass%
Poultry Fat	46
Yellow Grease	18
Brown Grease	18
Floatation Grease	9
Prepared Foods	9

It is not stated but from previous discussions we may assume this is a representative recipe for the available waste FOG materials. The 'Floatation Grease' is most likely to be representative of material collected from sewage skimmers. 'Brown Grease' would be the kind of materials collected from grease traps. So the FOG blend has a significant amount of bad material in it to start.

The report goes on to detail the efforts made to clean this material sufficiently to be able to start the hydroprocessing effort. It even includes a description of a unique cleaning process that goes beyond the normal washing recommendations. (The process may be Syntroleum IP so we will leave it undefined). They even provided a unique illustration of the change in the material from FOG to Petroleum Wax to HRJ SPK: (see Figure B-1).

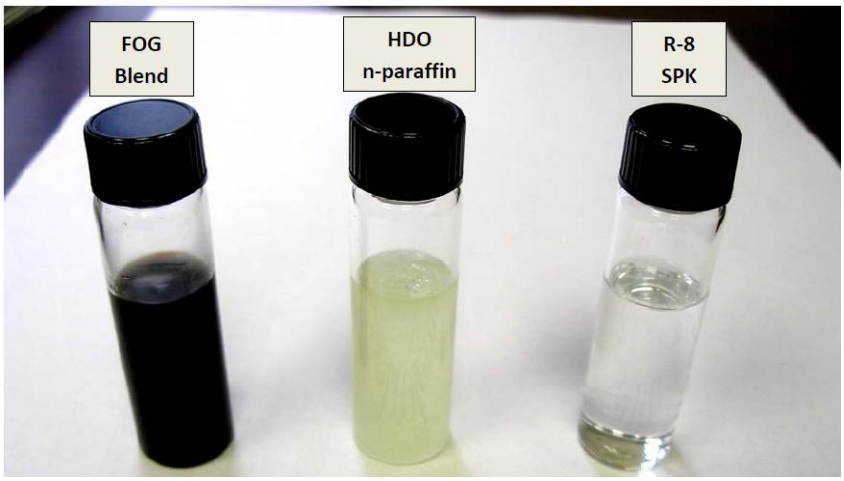

Figure B-1. FOG Blend Processing

The important point is that if anyone wants to process FOG there will be significant cleaning required before it can even start the conversion process. According to the Syntroleum report there is even a pre-treatment catalyst to remove the remaining metals before starting into the hydroprocessing.

The data so far shows there are no issues with the R-8 as an HRJ SPK so it seems the process sufficiently isolates the resulting material from its humble origins. Regardless the question of origin argues for completing the blend studies as we recommend.

4.3 Pump Wear Testing

In the first round of R-8 testing, we ran the standard U.S. Army test for pump wear and found, as expected, the neat material, based on the raw BOCLE value, to have severe wear characteristics. In this round of testing a separate program was organized to continue that study with additized neat and blended (with JP-8) R-8. The results are reported separately in SwRI Report "*R8 Rotary Fuel Injection Pump Wear Testing*" (SwRI Project No. 14406.03) but a short discussion is pertinent to the suitability discussion.

For the tests with the lubricity additive present, the neat R-8 and R-8 / JP-8 passed the full test duration. This is strong evidence that the standard military CI/LI materials approved in QPL25017 are still as good at providing lubricity protection with synthetic jet fuel as with refined jet fuel. There were some flow anomalies with the additized neat material but not outside of the limits of the test. They may well be due to the density and viscosity of the base R-8 (Table B1-1). While the admixtures of dimer / trimer linoleic acid have proven reasonably successful in providing lubricity for jet fuel they do not work well for #2 Diesel, of which the U.S. Army consumes a significant amount.

4.4 A Note on the R-8 / Jet A Blend

We found that the Jet A that was used to make the 50/50 R-8 / Jet A blend had some unusual properties (high flash point and low freeze point). This fuel is purchased in bulk from a local refinery and still meets the D1655 specification. To verify that the R-8 blend behaves as expected with a typical Jet A, we made an additional test blend and re-tested the flash point and freeze point. The results are reported in Table B-2.

Table B-2. Results for R-8 Blend with an Alternative Jet A

SwRI Sample Code			CL09-00984	CL09-00980
Test	Method	Units	Clay-Treated Jet A	50/50 R-8 / CT Jet A
Freeze Point (manual)	D2386	°C	-48.0	-47.4
Freeze Point	D5972	°C	-46.6	-48.1
Flash Point - Pensky-Martens Closed Cup	D93	°C	38.5	42.5

While the data generated with the original blend (Table B1-1) and the re-tests (Table B-2) appear satisfactory, we recommend that these be repeated in the follow-on effort to do all of the blended fuel FFP testing.

5.0 Summary and Recommendations

The neat R-8 has satisfactory characteristics as an HRJ SPK blending material in all aspects. The limited blend testing conducted in this program suggested that any resulting blend would be just as satisfactory. In line with the interest of using this material as one of key justifications in approving the inclusion of HRJ SPK in D7566 and the questions regarding its humble origin we are recommending that the complete FFP protocol, including Table 1 data for the jet fuel and the resulting blend, be conducted on a fresh sample of R-8.

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Appendix B1

R-8 HRJ SPK Data

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Table B1-1. Results for R-8 HRJ SPK

SwRI Sample Code			CL09-00324	CL09-00325
Test	**Method**	**Units**	**R-8 HRJ SPK**	**50/50 R-8 / Jet-A**
Surface tension	D1331A			
-10°C		mN/m	26.8	--
23°C		mN/m	24.4	--
40°C		mN/m	23.0	--
Freeze Point (manual)	D2386	°C	-49.0	--
Hydrocarbon Types by Mass Spec	D2425			
Paraffins		mass%	90.20	--
Monocycloparaffins		mass%	8.90	--
Dicycloparaffins		mass%	0.00	--
Tricycloparaffins		mass%	0.00	--
Alkylbenzenes		mass%	0.90	--
Electrical Conductivity vs. SDA Concentration (Stadis 450)	D2624			
0 mg/L		pS/m	10	0
1 mg/L		pS/m	320	300
2 mg/L		pS/m	580	590
3 mg/L		pS/m	1690	830
4 mg/L		pS/m	3200	1050
Copper by AA	D3237M	ppm	0.013	--
JFTOT Breakpoint	D3241BP			
Test Temperature		°C	>340	--
ASTM Code		rating	>2	--
Maximum Pressure Drop		mm Hg	0.1	--
JFTOT deposit thickness	D3241BP			
280°C		nm	15.52	--
300°C		nm	19.26	--
320°C		nm	20.77	--
330°C		nm	21.67	--
340°C		nm	24.36	--
Acid Number	D3242	mg KOH/g	0.004	--
Storage Stability - Peroxides @65°C	D3703			
0 week		mg/kg	3.2	--
1 week		mg/kg	5.6	--
2 week		mg/kg	7.2	--
3 week		mg/kg	1.6	--
6 week		mg/kg	6.7	--
Density	D4052			
0°C		g/mL	0.7742	0.7984
15°C		g/mL	0.7632	0.7872

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Table B1-1. Results for R-8 HRJ SPK

SwRI Sample Code			CL09-00324	CL09-00325
Test	**Method**	**Units**	**R-8 HRJ SPK**	**50/50 R-8 / Jet-A**
40°C		g/mL	0.7449	0.7685
60°C		g/mL	0.7322	0.7564
80°C		g/mL	0.7182	0.7424
Kinematic Viscosity	D445			
-40°C		cSt	12.59	11.29
20°C		cSt	2.30	2.11
40°C		cSt	1.49	1.45
Nitrogen Content	D4629	mg/kg	0.10	--
Lubricity (BOCLE) vs. CI/LI Concentration (DCI-4A)	D5001			
0 mg/L		mm	0.90	--
5 mg/L		mm	0.59	--
10 mg/L		mm	0.57	--
15 mg/L		mm	0.54	--
20 mg/L		mm	0.54	--
Vapor Pressure (Triple Expansion)	D6378			
0°C		psig	0.16	0.22
10°C		psig	0.20	0.26
20°C		psig	0.24	0.31
30°C		psig	0.27	0.36
40°C		psig	0.32	0.47
50°C		psig	0.39	0.55
60°C		psig	0.50	0.69
70°C		psig	0.65	0.88
80°C		psig	0.87	1.14
90°C		psig	1.17	1.51
100°C		psig	1.58	1.98
110°C		psig	2.12	2.60
120°C		psig	2.87	3.45
Carbon/Hydrogen	D5291			
Carbon		%	86.32	--
Hydrogen		%	14.12	--
Storage Stability – Potential Gums	D5304			
16 hours		mg/100mL	0.40	--
Freeze Point	D5972	°C	-49.1	-57.8
Isothermal Tangent Bulk Modulus, 30°C	D6793			
0 psig		psig	193859	--
1000 psig		psig	203786	--
2000 psig		psig	213958	--
3000 psig		psig	224376	--
4000 psig		psig	235039	--

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Table B1-1. Results for R-8 HRJ SPK

SwRI Sample Code			CL09-00324	CL09-00325
Test	Method	Units	R-8 HRJ SPK	50/50 R-8 / Jet-A
5000 psig		psig	245948	--
6000 psig		psig	257102	--
7000 psig		psig	268501	--
8000 psig		psig	280146	--
9000 psig		psig	292036	--
10000 psig		psig	304171	--
Isothermal Tangent Bulk Modulus, 60°C	D6793			
0 psig		psig	165137	--
1000 psig		psig	175779	--
2000 psig		psig	186750	--
3000 psig		psig	198051	--
4000 psig		psig	209680	--
5000 psig		psig	221640	--
6000 psig		psig	233928	--
7000 psig		psig	246546	--
8000 psig		psig	259493	--
9000 psig		psig	272770	--
10000 psig		psig	286375	--
Elemental Analysis	D7111			
Al		ppb	101	--
Ba		ppb	<100	--
Ca		ppb	<100	--
Cr		ppb	<100	--
Cu		ppb	<100	--
Fe		ppb	<100	--
Li		ppb	<100	--
Pb		ppb	<100	--
Mg		ppb	<100	--
Mn		ppb	<100	--
Mo		ppb	<100	--
Ni		ppb	<100	--
K		ppm	<1	--
Na		ppm	1.3	--
Si		ppb	<100	--
Ag		ppb	<100	--
Ti		ppb	<100	--
V		ppb	<100	--
Zn		ppb	<100	--
Distillation	D86			
IBP		°C	156.4	--
5%		°C	171.7	--

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Table B1-1. Results for R-8 HRJ SPK

SwRI Sample Code			CL09-00324	CL09-00325
Test	**Method**	**Units**	**R-8 HRJ SPK**	**50/50 R-8 / Jet-A**
10%		°C	177.7	--
15%		°C	181.8	--
20%		°C	188.3	--
30%		°C	196.8	--
40%		°C	207.1	--
50%		°C	217.5	--
60%		°C	227.7	--
70%		°C	238.7	--
80%		°C	250.5	--
90%		°C	263.0	--
95%		°C	270.9	--
FBP		°C	273.9	--
Residue		%	1.5	--
Loss		%	1.3	--
Distillation Slope	D86			
T50-T10		°C	39.8	--
T90-T10		°C	85.3	--
Calculated Cetane Index	D976	--	67.2	--
Calculated Cetane Index	D4737 Proc A	--	72.4	--
Specific Heat Capacity	E2716		Cp = 0.0039*T + 1.9243	Cp = 0.0037*T + 1.9145
-30°C		kJ/kg.K	1.808	1.804
0°C		kJ/kg.K	1.924	1.915
50°C		kJ/kg.K	2.118	2.099
100°C		kJ/kg.K	2.312	2.284
150°C		kJ/kg.K	2.505	2.468
Minimum Ignition Energy	E582	mJ	0.63	--
Autoignition temperature	E659			
Hot Flame Autoignition Temperature		°C	222	227
Hot Flame Lag Time		seconds	6.0	163.0
Cool Flame Autoignition Temperature		°C	--	224
Cool Flame Lag Time		seconds	--	216.0
Barometric Pressure		mm Hg	740.3	736.4
Reaction Threshold Temperature		°C	201	213
Upper Explosion Limit (UEL), @150°C	E681	%	4.3	--
Lower Explosion Limit (LEL)	E681			
@100°C		%	0.4	--
@ 150°C		%	0.3	--
Carbonyls, Alcohols, Esters, Phenols				

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Table B1-1. Results for R-8 HRJ SPK

SwRI Sample Code			CL09-00324	CL09-00325
Test	**Method**	**Units**	**R-8 HRJ SPK**	**50/50 R-8 / Jet-A**
Alcohols	EPA 8015B	ppm	<5	--
Carbonyls, Esters	EPA 8260B	ppb	<1	--
Phenols	EPA 8270C	ppm	<50	--
Hot surface ignition	FTM 791-6053	°F	1250	--
Elastomer Compatibility (O-Ring Tests)	various	--	See Figure B1-1 ,Figure B1-2, and Figure B1-3	--
Dielectric Constant (400Hz)	SwRI			
-31.2°C		--	2.0894	--
-20.1°C		--	2.0760	--
-4°C		--	2.0562	--
17.9°C		--	2.0299	--
49.2°C		--	1.9946	--
81°C		--	1.9578	--
Dielectric Constant (400Hz)	SwRI			
-37.9°C		--	--	2.1512
-18°C		--	--	2.1244
1.2°C		--	--	2.0992
20.2°C		--	--	2.0743
50.8°C		--	--	2.0374
81°C		--	--	1.9999
Thermal Conductivity	SwRI			
0°C		W/m.K	0.1100	0.1057
25°C		W/m.K	0.1080	0.1025
50°C		W/m.K	0.1059	0.0994
Aromatic Content	D5186			
Total Aromatics		mass%	1.0	--
Mononuclear Aromatics		mass%	0.9	--
Polynuclear Aromatics		mass%	0.1	--

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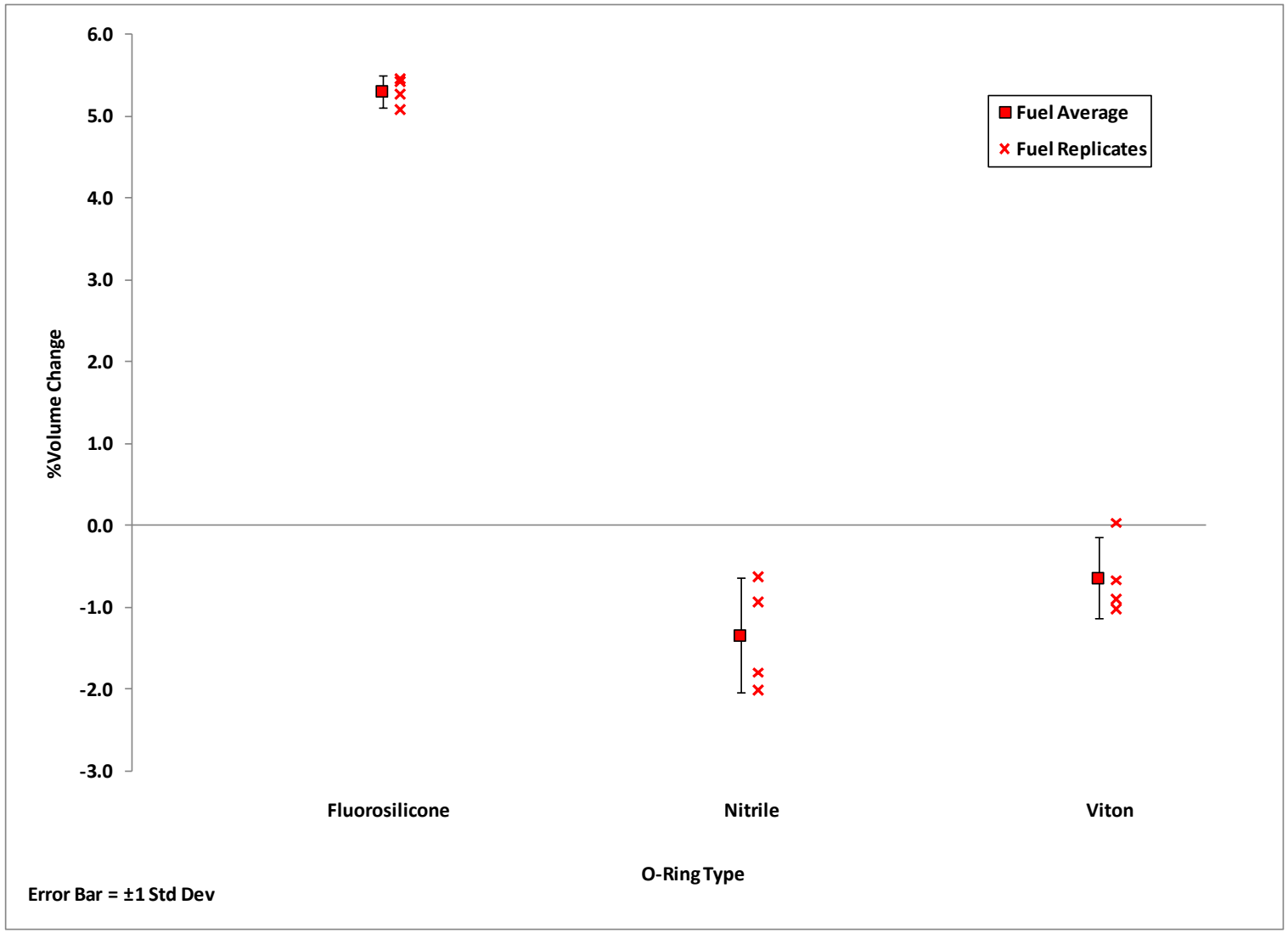

Figure B1-1. O-Ring Volume Change – R-8

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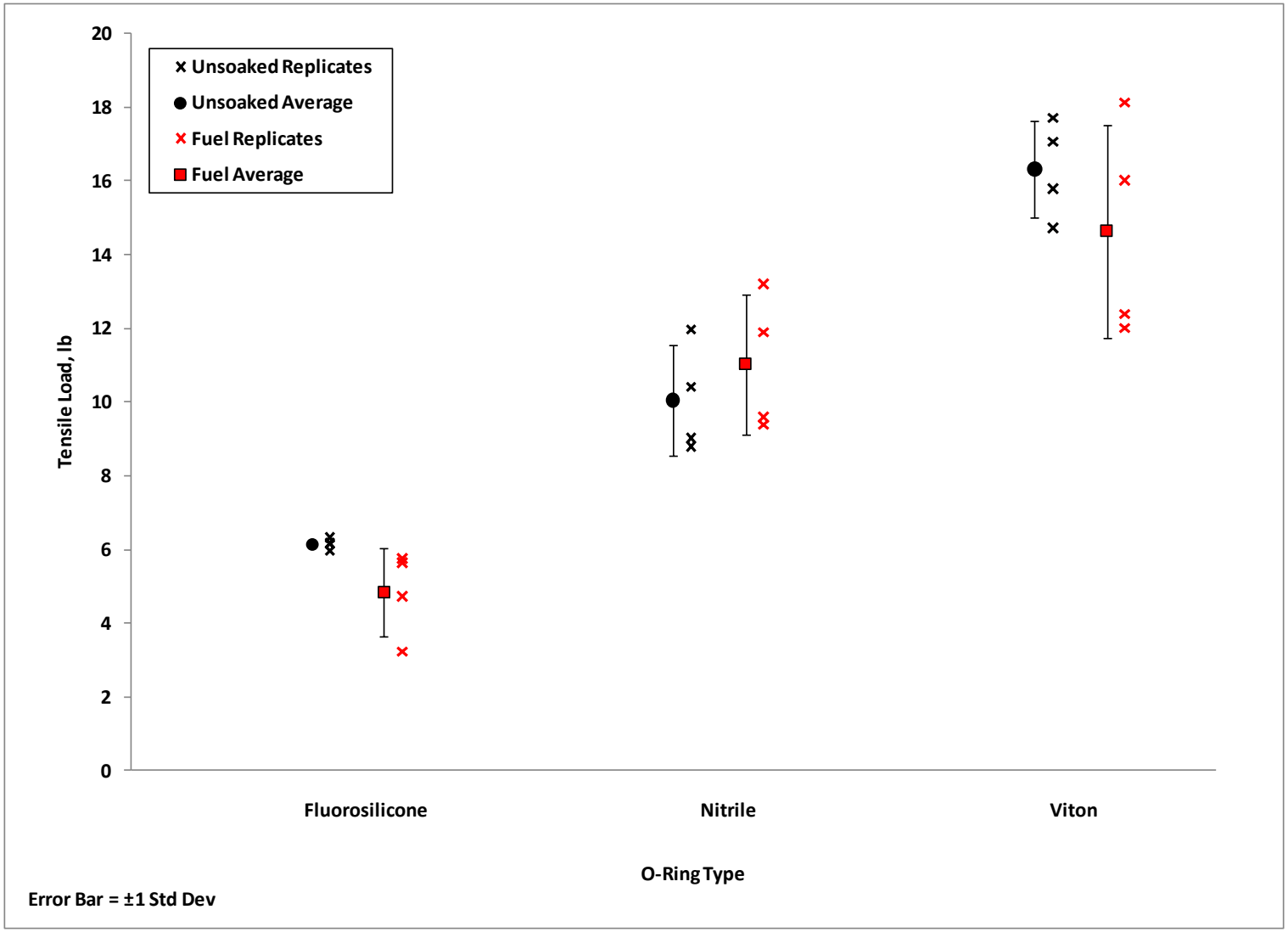

Figure B1-2. O-Ring Tensile Load – R-8

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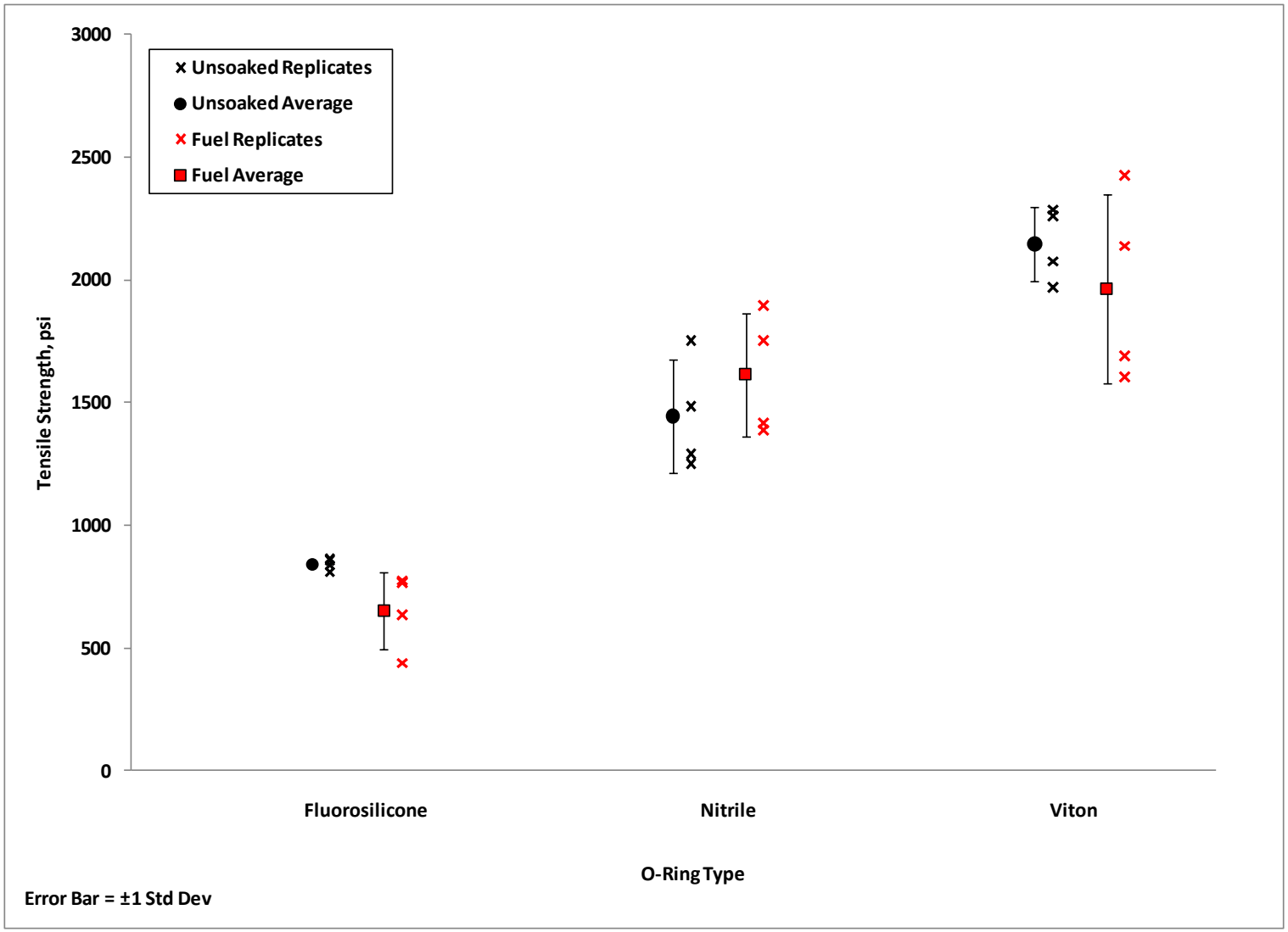

Figure B1-3. O-Ring Tensile Strength – R-8

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Appendix C

R-8x Report

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EVALUATION OF R-8X

FINAL REPORT
SwRI® Project No. 08-14406.04.002

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November 2010

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Executive Summary

Syntroleum® R-8X HRJ SPK (synthetic paraffinic kerosine derived from hydroprocessed fats and oils) is a jet fuel blending material made from oil produced from halophytes. Halophytes are plants that grow in high salinity with brackish water. There are significant international efforts to develop these plants as energy sources in order to utilize otherwise unproductive coastal lands. Halophytes potentially can provide both oil and cellulosic feed stocks for conversion. R-8X is an example of a potential product.

R-8X was produced in limited quantities using the same process used to produce Syntroleum R-8, a HRJ SPK derived from waste fats, oils and greases. With a limited quantity available SwRI was only able to do a selected subset of the tests required to establish Fit-for-Purpose (FFP). The results for most of the tests were essentially the same as for R-8, with the minor variation likely due to the differences in the feedstock fatty acid distribution.

The only failure was in Thermal Stability, ASTM D3241. A properly prepared HRJ SPK should have a minimum breakpoint of 325°C. This particular sample failed at the blended fuel specification requirement of 260°C. The SwRI review of the data, the nature of the failure and a comparison with results from the R-8 sample produced by the same process suggests this was just a process finishing or sampling issue.

Based on the limited data available it appears that it would be possible to make a suitable HRJ SPK from oil derived from halophytes. This is consistent with the existing data that indicates that the hydroprocessing of organic fats and oils produces high quality SPK regardless of the source.

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1.0 Objective

The objective of this task was to do a selected set of analyses on a limited amount of R-8X to get a reasonable impression of how this material would work as a Hydroprocessed Renewable Jet (HRJ) Synthetic Paraffinic Kerosene (SPK).

2.0 Background

At the end of the program to make R-8, Syntroleum was asked to make a modest batch of SPK from halophyte oil. This produced a very limited quantity of prototypical HRJ SPK. SwRI was asked to propose a program that would do as much of the Fit-for-Purpose (FFP) testing as possible with two gallons of fuel.

3.0 Samples

SwRI was provided with approximately 10 liters of R-8X SPK from AFRL. The sample was identified as POSF5470 and assigned SwRI sample number CL09-00636.

4.0 Summary and Conclusions

(The R-8X test results can be found in Appendix Table C1-2.)

For the tests conducted, R-8X looked pretty much like a typical HRJ SPK. There was an issue with the D3241 Thermal Stability test however as it failed in SwRI testing.

The D3241 Breakpoint for an HRJ SPK is expected to be at least 325°C. With the limited quantity of R-8X, SwRI recommended only testing at the common fuel limit of 260°C. In SwRI testing, the R-8X failed with a rating of 2A (A = Abnormal). The Abnormal rating is not uncommon as a source of D3241 failures in the fuel distribution system and is often associated with a cleanliness issue. It is also a very subjective rating and the same deposit can be seen as 'Normal' by other raters. (AFRL ran the same test at 260°C and passed the test.) In general we feel this was just a 'finishing' issue driven by a limited amount of material being processed. With the rest of the data showing very normal results we suspect a full batch of product would have no trouble reaching the minimum 325°C breakpoint required for SPK.

Based on the limited results of tests conducted with the R-8X sample provided, we see no issue in generating a suitable HRJ SPK from halophytes. This is another point of information that reinforces the general proposition that HRJ SPK can be made from any source of organic fats and oils. It is recommended, if sufficient sample remains, that 3 liters of this material be clay treated and subjected to Breakpoint analysis.

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Appendix C1

Data

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Table C1-2. Results for R-8x (POSF5470)

SwRI Sample Code			CL09-00636
Test	**Method**	**Units**	**R-8x (POSF 5470)**
Water Reaction	D1094		
Aqueous layer volume change		mL	1.0
Interface Rating		rating	1
Degree of Separation		rating	1
Copper Strip Corrosion (2 hrs @ 100°C)	D130	rating	1A
Aromatic Content	D1319		
Aromatics		vol%	0.7
Olefins		vol%	0.5
Saturates		vol%	98.80
Smoke Point	D1322	mm	41.0
Surface tension	D1331A		
-10°C		mN/m	26.1
22°C		mN/m	23.8
40°C		mN/m	22.3
Saybolt Color	D156	rating	+30
Naphthalene Content	D1840	vol%	0.33
Freeze Point (manual)	D2386	°C	-56.0
Hydrocarbon Types by Mass Spec	D2425		
Paraffins		mass%	87.9
Monocycloparaffins		mass%	11.2
Dicycloparaffins		mass%	0.0
Tricycloparaffins		mass%	0.0
Alkylbenzenes		mass%	0.9
Sulfur - Mercaptan	D3227	mass%	<0.0003
JFTOT	D3241		
Test Temperature		°C	260
ASTM Code		rating	2A
Maximum Pressure Drop		mm Hg	0
JFTOT deposit thickness	D3241		
260°C		nm	30.17
Acid Number	D3242	mg KOH/g	0.006
Specific Energy (calculated, sulfur corrected)	D3338	MJ/kg	44.078
Hydrogen Content (NMR)	D3701	mass%	15.24
Storage Stability - Peroxides @65°C	D3703		
0 week		mg/kg	0.0
1 week		mg/kg	5.6
2 week		mg/kg	14.3
3 week		mg/kg	7.2
6 week		mg/kg	6.3
Existent Gums	D381		
Washed		mg/100mL	<0.5
Unwashed		mg/100mL	<0.5
MSEP	D3948	rating	99
Density	D4052		
0°C		g/mL	0.7719

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Table C1-2. Results for R-8x (POSF5470)

SwRI Sample Code			CL09-00636
Test	**Method**	**Units**	**R-8x (POSF 5470)**
15°C		g/mL	0.7607
40°C		g/mL	0.7424
60°C		g/mL	0.7276
80°C		g/mL	0.7126
Kinematic Viscosity	D445		
-20°C		cSt	5.08
0°C		cSt	2.89
40°C		cSt	1.34
100°C		cSt	0.74
Specific Energy (calculated, sulfur corrected)	D4529	MJ/kg	44.088
Nitrogen Content	D4629	mg/kg	<1
Heat of Combustion	D4809		
BTUHeat_Gross		BTU/lb	20281.6
BTUHeat_Net		BTU/lb	18883.1
MJHeat_Gross		MJ/kg	47.18
MJHeat_Net		MJ/kg	43.92
Lubricity (BOCLE) vs. CI/LI Concentration	D5001		
0 mg/L		mm	0.94
5 mg/L		mm	0.85
10 mg/L		mm	0.72
15 mg/L		mm	0.64
20 mg/L		mm	0.60
Vapor pressure	D6378		
0°C		psig	0.17
10°C		psig	0.20
20°C		psig	0.24
30°C		psig	0.28
40°C		psig	0.34
50°C		psig	0.41
60°C		psig	0.53
70°C		psig	0.71
80°C		psig	0.96
90°C		psig	1.30
100°C		psig	1.77
110°C		psig	2.37
120°C		psig	3.20
Carbon/Hydrogen	D5291		
Carbon		%	84.86
Hydrogen		%	15.33
Storage Stability – Potential Gums	D5304		
16 hours		mg/100mL	1
Sulfur Content - (Antek)	D5453	ppm	0.6
Freeze Point	D5972	°C	-52.3
Aniline Point	D611	°C	82.4
Isothermal Tangent Bulk Modulus, 30°C	D6793		
0 psig		psig	186226

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Table C1-2. Results for R-8x (POSF5470)

SwRI Sample Code			CL09-00636
Test	**Method**	**Units**	**R-8x (POSF 5470)**
1000 psig		psig	196986
2000 psig		psig	208046
3000 psig		psig	219406
4000 psig		psig	231065
5000 psig		psig	243024
6000 psig		psig	255283
7000 psig		psig	267841
8000 psig		psig	280698
9000 psig		psig	293856
10000 psig		psig	307313
Isothermal Tangent Bulk Modulus, 60°C	D6793		
0 psig		psig	157204
1000 psig		psig	168213
2000 psig		psig	179591
3000 psig		psig	191339
4000 psig		psig	203456
5000 psig		psig	215943
6000 psig		psig	228800
7000 psig		psig	242025
8000 psig		psig	255621
9000 psig		psig	269585
10000 psig		psig	283920
Distillation	D86		
IBP		°C	154.1
5%		°C	167.1
10%		°C	170.7
15%		°C	175.9
20%		°C	180.3
30%		°C	188.6
40%		°C	198.3
50%		°C	208.2
60%		°C	218.0
70%		°C	228.3
80%		°C	239.9
90%		°C	253.9
95%		°C	263.3
FBP		°C	267.9
Residue		%	1.5
Loss		%	1.1
Distillation Slope	D86		
T50-T10		°C	37.5
T90-T10		°C	83.2
Flash Point - Pensky-Martens Closed Cup	D93	°C	47
Calculated Cetane Index	D976	--	65.0
Specific Heat Capacity	E1269		Cp = 0.0035*T + 1.9637
-30°C		kJ/kg.K	1.860

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Table C1-2. Results for R-8x (POSF5470)

SwRI Sample Code			CL09-00636
Test	**Method**	**Units**	**R-8x (POSF 5470)**
0°C		kJ/kg.K	1.964
50°C		kJ/kg.K	2.136
100°C		kJ/kg.K	2.309
150°C		kJ/kg.K	2.482
Carbonyls, Alcohols, Esters, Phenols			
Alcohols	EPA 8015B	ppm	<5
Carbonyls, Esters	EPA 8260B	ppb	<1
Phenols	EPA 8270C	ppm	<50
Thermal Conductivity	SwRI		
0°C		W/m.K	0.1072
25°C		W/m.K	0.1062
50°C		W/m.K	0.1053
Aromatic Content	D5186		
Total Aromatics		mass%	1.1
Mononuclear Aromatics		mass%	1.1
Polynuclear Aromatics		mass%	0.0

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Appendix D

Boeing Flight Fuels Data

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Table D-1. Results for Boeing Flight Fuels

SwRI Sample Code			CL09-0501	CL09-0502	CL09-0503	CL09-00500
Test	**Method**	**Units**	**Jet / JAL 50% Blend (POSF5674)**	**Jet / CAL 50% Blend (POSF5675)**	**Jet / ANZ 50% Blend (POSF5673)**	**Jatropha/Algae (Neat)**
Copper Strip Corrosion (3 hrs at 100°C)	D130	rating	1b	1b	1a	--
Aromatic Content	D1319					
Aromatics		vol%	8.7	9.1	9.3	--
Olefins		vol%	0.7	0.5	0.7	--
Saturates		vol%	90.6	90.4	90.0	--
Smoke Point	D1322	mm	21	25	23	--
Surface tension	D1331A					
-10°C		mN/m	26.8	26.6	27.0	--
22°C		mN/m	24.9	24.6	24.5	--
40°C		mN/m	23.1	22.3	22.6	--
Naphthalene Content	D1840	vol%	1.28	0.25	0.44	--
Freeze Point (manual)	D2386	°C	-57.0	-59.4	-62.5	--
Hydrocarbon Types by Mass Spec	D2425					
Paraffins		mass%	58.1	64.50	63.5	--
Monocycloparaffins		mass%	16.5	24.90	24.6	--
Dicycloparaffins		mass%	11.2	0.00	0.0	--
Tricycloparaffins		mass%	2.9	0.00	0.0	--
TOTAL SATURATES		mass%	88.7	89.40	88.1	--
Alkylbenzenes		mass%	5.3	6.40	7.3	--
Indans / Tetralins		mass%	3.0	3.40	3.5	--
Indenes		mass%	0.6	0.00	0.0	--
Naphthalene		mass%	0.4	0.30	0.4	--
Naphthalene, Alkyl		mass%	1.6	0.30	0.6	--
Acenaphthenes		mass%	0.2	0.10	0.0	--
Acenaphthylenes		mass%	0.2	0.10	0.1	--
Tricyclic Aromatics		mass%	0.0	0.00	0.0	--
TOTAL AROMATICS		mass%	11.3	10.60	11.9	--
Electrical Conductivity vs. SDA Concentration (Stadis 450)	D2624					
0 mg/L		pS/m	0	0	0	--
1 mg/L		pS/m	430	420	410	--
2 mg/L		pS/m	820	870	730	--
3 mg/L		pS/m	1170	1290	1110	--
4 mg/L		pS/m	1520	1600	1440	--
Simulated Distillation	D2887					
IBP		°C	117.2	119.9	114.8	--
5%		°C	144.3	144.8	144.7	--
10%		°C	150.3	152.5	152.7	--
15%		°C	161.2	161.5	160.9	--

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Table D-1. Results for Boeing Flight Fuels

SwRI Sample Code			CL09-0501	CL09-0502	CL09-0503	CL09-00500
Test	**Method**	**Units**	**Jet / JAL 50% Blend (POSF5674)**	**Jet / CAL 50% Blend (POSF5675)**	**Jet / ANZ 50% Blend (POSF5673)**	**Jatropha/Algae (Neat)**
20%		°C	168.5	168.1	167.4	--
30%		°C	182.0	177.2	175.0	--
40%		°C	192.5	189.5	185.1	--
50%		°C	204.0	198.9	193.1	--
60%		°C	215.2	209.4	203.6	--
70%		°C	227.8	219.3	213.0	--
80%		°C	239.5	230.3	225.5	--
90%		°C	256.0	243.9	241.0	--
95%		°C	265.9	255.4	255.0	--
FBP		°C	288.3	279.3	274.2	--
Sulfur - Mercaptan	D3227	mass%	<0.0003	<0.0003	<0.0003	--
JFTOT Breakpoint	D3241BP					
Test Temperature		°C	275	285	265	--
ASTM Code		rating	2	1	1	--
Maximum Pressure Drop		mm Hg	0	0	0	--
Specific Energy (calculated, sulfur corrected)	D3338	MJ/kg	43.55	43.64	43.63	--
Hydrogen Content (NMR)	D3701	mass%	14.39	14.65	14.49	--
Storage Stability - Peroxides @65°C	D3703					
0 week		mg/kg	5.6	7.1	6.8	--
1 week		mg/kg	0.0	0.0	0.0	--
2 week		mg/kg	1.6	0.0	0.0	--
3 week		mg/kg	0.0	0.0	0.0	--
6 week		mg/kg	1.0	0.5	1.3	--
Existent Gums	D381					
Unwashed		mg/100mL	<1	<1	<1	--
MSEP	D3948	rating	99	99	98	--
Density	D4052					
5°C		g/mL	0.7966	0.7872	0.7868	--
15°C		g/mL	0.7891	0.7797	0.7793	--
25°C		g/mL	0.7817	0.7723	0.7718	--
40°C		g/mL	0.7706	0.7613	0.7606	--
60°C		g/mL	0.7556	0.7460	0.7454	--
80°C		g/mL	0.7406	0.7309	0.7302	--
Kinematic Viscosity	D445					
-20°C		cSt	4.56	4.27	4.18	--
0°C		cSt	2.68	2.58	2.55	--
40°C		cSt	1.51	1.50	1.40	--
100°C		cSt	0.85	0.87	0.79	--
Specific Energy (calculated, sulfur corrected)	D4529	MJ/kg	43.560	43.666	43.651	--
Heat of Combustion	D4809					

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Table D-1. Results for Boeing Flight Fuels

SwRI Sample Code			CL09-0501	CL09-0502	CL09-0503	CL09-00500
Test	**Method**	**Units**	**Jet / JAL 50% Blend (POSF5674)**	**Jet / CAL 50% Blend (POSF5675)**	**Jet / ANZ 50% Blend (POSF5673)**	**Jatropha/Algae (Neat)**
Heat_Gross		BTU/lb	19927.4	20000.6	20009.2	--
Heat_Net		BTU/lb	18614.6	18661.4	18680.8	--
Heat_Gross		MJ/kg	46.34	46.51	46.53	--
Heat_Net		MJ/kg	43.29	43.40	43.44	--
Lubricity (BOCLE) vs. CI/LI Concentration (DCI-4A)	D5001					
0 mg/L		mm	0.73	0.81	0.60	0.97
5 mg/L		mm	0.62	0.68	0.63	0.78
10 mg/L		mm	0.60	0.59	0.59	0.74
15 mg/L		mm	0.58	0.54	0.59	0.68
20 mg/L		mm	0.54	0.56	0.56	0.61
Vapor Pressure	D6378					
0 °C		psia	0.18	0.16	0.21	0.17
10 °C		psia	0.23	0.21	0.29	0.21
20 °C		psia	0.28	0.26	0.34	0.26
30 °C		psia	0.32	0.29	0.38	0.31
40 °C		psia	0.38	0.34	0.45	0.39
50 °C		psia	0.46	0.42	0.55	0.53
60 °C		psia	0.59	0.54	0.69	0.75
70 °C		psia	0.77	0.71	0.90	1.04
80 °C		psia	1.01	0.96	1.18	1.42
90 °C		psia	1.36	1.31	1.57	1.95
100 °C		psia	1.84	1.78	2.10	2.64
110 °C		psia	2.46	2.41	2.80	3.56
120 °C		psia	3.31	3.27	3.78	5.26
Carbon/Hydrogen	D5291					
Carbon		%	85.50	85.50	85.49	--
Hydrogen		%	14.39	14.58	14.56	--
Storage Stability – Potential Gums	D5304					
16 hours		mg/100mL	1.0	0.7	0.5	--
Sulfur Content - (Antek)	D5453	ppm	399.7	0.8	84.8	--
Flash Point - Tag Closed	D56	°C	113	115	111	--
Freeze Point	D5972	°C	-57.0	-59.2	-63.8	--
Aniline Point	D611	°C	68.3	69.3	68.4	--
Water Content	D6304					
~0°C		ppm	41	53	42	--
~22°C		ppm	69	74	69	--
~40°C		ppm	124	123	128	--
~60°C		ppm	236	243	222	
Isothermal Tangent Bulk Modulus, 30°C	D6793					

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Table D-1. Results for Boeing Flight Fuels

SwRI Sample Code			CL09-0501	CL09-0502	CL09-0503	CL09-00500
Test	Method	Units	Jet / JAL 50% Blend (POSF5674)	Jet / CAL 50% Blend (POSF5675)	Jet / ANZ 50% Blend (POSF5673)	Jatropha/Algae (Neat)
0 psig		psig	196952	195329	194304	--
1000 psig		psig	207116	205540	204364	--
2000 psig		psig	217534	216008	214675	--
3000 psig		psig	228204	226734	225238	--
4000 psig		psig	239128	237717	236052	--
5000 psig		psig	250305	248958	247117	--
6000 psig		psig	261736	260457	258434	--
7000 psig		psig	273420	272213	270002	--
8000 psig		psig	285357	284227	281821	--
9000 psig		psig	297547	296499	293892	--
10000 psig		psig	309990	309028	306214	--
Isothermal Tangent Bulk Modulus, 60°C a	D6793					
0 psig		psig	168620	165633	161888	--
1000 psig		psig	179125	176288	172306	--
2000 psig		psig	189945	187271	183045	--
3000 psig		psig	201080	198584	194106	--
4000 psig		psig	212529	210227	205489	--
5000 psig		psig	224293	222198	217194	--
6000 psig		psig	236371	234499	229221	--
7000 psig		psig	248764	247128	241570	--
8000 psig		psig	261472	260087	254240	--
9000 psig		psig	274494	273375	267232	--
10000 psig		psig	287831	286992	280546	--
Distillation	D86					
IBP		°C	156.6	160.4	158.0	--
5%		°C	169.5	170.9	169.0	--
10%		°C	171.3	172.5	170.5	--
15%		°C	175.1	174.4	173.0	--
20%		°C	178.8	177.5	174.2	--
30%		°C	185.4	182.5	180.3	--
40%		°C	193.0	188.3	185.3	--
50%		°C	201.3	195.1	191.4	--
60%		°C	210.1	202.0	198.3	--
70%		°C	219.2	210.1	206.0	--
80%		°C	229.5	218.7	215.8	--
90%		°C	242.5	230.7	229.6	--
95%		°C	253.1	240.4	241.2	--
FBP		°C	258.3	248.9	247.9	--
Residue		%	1.2	1.5	1.4	--
Loss		%	1.4	0.8	1.2	--

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Table D-1. Results for Boeing Flight Fuels

SwRI Sample Code			CL09-0501	CL09-0502	CL09-0503	CL09-00500
Test	**Method**	**Units**	**Jet / JAL 50% Blend (POSF5674)**	**Jet / CAL 50% Blend (POSF5675)**	**Jet / ANZ 50% Blend (POSF5673)**	**Jatropha/Algae (Neat)**
Flash Point – PMCC	D93	°C	49.0	49.5	47.5	--
Specific Heat Capacity	E2716	kJ/kg.K	Table 3	Table 3	Table 3	--
Minimum Ignition Energy	E582	mJ	0.46	0.46	0.46	--
Autoignition Temperature	E659					
Hot Flame Autoignition Temperature		°C	230	233	226	--
Hot Flame Lag Time		seconds	175	111	225	--
Cool Flame Autoignition Temperature		°C	--	--	--	--
Cool Flame Lag Time		seconds	0	0	0	--
Barometric Pressure		mm Hg	738.9	737.3	736.7	--
Reaction Threshold Temperature		°C	218	221	217	--
Upper Explosion Limit (UEL), @100°C	E681	%	6.0	5.8	3.5	--
Lower Explosion Limit (LEL), @100°C	E681	%	0.5	0.4	0.5	--
Hot Surface Ignition Temperature	FTM 791-6053	°F	1200	1250	1150	--
Removal of Emulsified Water	SAE J1488	TWA WRE **	100% Table D-2	--	--	--
Thermal Conductivity	SwRI					
0°C		W/m.K	0.1048	0.09930	0.09939	--
25°C		W/m.K	0.1036	0.09782	0.09855	--
50°C		W/m.K	0.1024	0.09634	0.09772	--
Ignition Quality Test (IQT)	D6890					
Ignition Delay, ID		ms	4.247	4.132	4.177	3.474
Derived Cetane Number, DCN		--	46.87	48.11	47.61	57.45
Dielectric Constant (400Hz)	SwRI					
-38.1°C		--	2.1632	--	--	--
-18.4°C		--	2.1362	--	--	--
1.9°C		--	2.1079	--	--	--
21°C		--	2.0830	--	--	--
50.5°C		--	2.0470	--	--	--
80.8°C		--	2.0084	--	--	--
Dielectric Constant (400Hz)	SwRI					
-37.7°C		--	--	2.1363	--	--
-22°C		--	--	2.1198	--	--
-1.6°C		--	--	2.0929	--	--
18.5°C		--	--	2.0673	--	--
42.9°C		--	--	2.0374	--	--
80.8°C		--	--	1.9901	--	--
Dielectric Constant (400Hz)	SwRI					
-37.2°C		--	--	--	2.1356	
-20.6°C		--	--	--	2.1148	
0.8°C		--	--	--	2.0894	
19.7°C		--	--	--	2.0649	
50.7°C		--	--	--	2.0255	
78.1°C		--	--	--	1.9898	

**** TWA WRE = Time Weighted Average Water Removal Efficiency**

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Table D-2. SAE J1488 Results for CL09-00501 (POSF5674) – Jet/JAL Blend

Test Description	SAE J1488	**Test No**	2
Test Engineer	Gary Bessee	**Filter ID**	M1
Test Fluid	CL09-00501	**Test Date**	7/16/2009
Vacuum / Pressure	Pressure	**Test Temperature, °C**	26.6
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	112.83

Fuel/Water Interfacial Tension (mN/m)

Before	35.8

MSEP

Before	93

Sample ID	Test Time (minutes)	Upstream (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from Test Filter (mL)
			Measured	Adjusted		
1	10	2490	53.48	0	7.5	74
2	30	2760	77.69	0	8.4	305
3	50	1980	47.94	0	9.8	300
4	70	2080	52.90	0	10.4	415
5	90	2600	55.62	0	10.5	475
6	110	2950	73.42	0	10.5	410
7	130	2980	55.38	0	11.1	320
8	150	2540	61.17	0	11.2	315

Average Water Content, ppm	2548
Time Weighted Average Water Removal Efficiency (%)	100.0%
Total Water from Test Housing (mL)	2540
Water from Cleanup Filters (mL)	0

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Appendix E

FT and HRJ Report

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FT-SPK and HRJ EVALUATION

FINAL REPORT
SwRI® Project No. 08-14406.01.003

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November 2010

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1.0 Objective

The purpose of this effort was to provide additional test data for selected Fischer-Tropsch (FT) Synthetic Paraffinic Kerosenes (SPK) and Hydroprocessed Renewable Jet (HRJ) fuels.

2.0 Samples

Nine fuel samples, identified in Table E-1, were selected for analysis. The Sasol GTL samples, the Syntroleum SPK, and the Shell SPK were on-hand at SwRI. The GTL samples had been clay treated prior to this study. The Sasol IPK was provided by AFRL. UOP provided four HRJ samples for testing.

Table E-1. FT and HRJ Samples

SwRI Sample No.	SwRI Alternate Sample No.	Description
CL09-00163	AL-28060	Sasol GTL#2 (Isomerized Kerosene)
CL09-00164	AL-28059	Sasol GTL#1 (FT-Kerosene)
CL09-00268	AL-28518	Sasol IPK (POSF5642)
CL09-00169	AL-27074	Syntroleum SPK
CL09-00170	AL-27892	Shell SPK
CL09-00171	AL-28594	08POSF5675 (UOP HRJ)
CL09-00172	AL-28592	08POSF5673 (UOP HRJ)
CL09-00173	AL-28593	08POSF5674 (UOP HRJ)
CL09-00174	AL-28595	08POSF5698 (UOP HRJ)

3.0 Analysis

The FT-SPK and HRJ results can be found in Table E1-1 and Table E1-2, respectively. Other than aromatic content and trace contaminants in the elemental analysis, the samples in this study generally meet the requirements of Table A1.2 in the D7566-09 specification for the tests performed. A discussion of specific issues follows.

3.1 Hydrogen Content

For comparison, hydrogen content was determined by two methods - ASTM D5291 and ASTM D3701. ASTM D3701, which is based on nuclear magnetic resonance (NMR), specifically cites a 1977 research report indicating a positive bias for known, pure compounds. No specific bias toward D5291 could be detected in this data. The hydrogen contents are plotted for comparison in Figure E1-1.

3.2 Aromatic Content

While most of the samples were shown to contain no detectable aromatic content, two samples, the Sasol IPK and 08POSF5698, narrowly exceeded the maximum allowable aromatic content of 0.5 mass% per D7566 (see Figure E1-2). Independent validation tests in our lab suggest that these values are significant (valid) and represent an actual response from aromatics in the fuel. However, the reproducibility of that value may be as high as 1.4 mass%. An ongoing investigation of the D2425 method is underway between SwRI and other labs.

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3.3 Elemental Analysis

ASTM D7111 (ICP-AES) was used to determine the elemental composition at SwRI. The specification limit (per UOP 389) is 100 ppb per element. All of the fuels contain at least one element that exceeds this maximum limit. These contaminants are relatively common and could have been acquired through normal transport and handling of the fuel. The most likely sources of these trace contaminants are as follows:

- Aluminum
  - Fuel containers (manufacturing debris)
  - Glass sample bottles
  - Drying agents (aluminosilicates)
- Lithium
  - Clay (used for clay treatment)
- Sodium
  - Glass sample bottles
- Silicon
  - Glass sample bottles
  - Drying agents (aluminosilicates)

4.0 Conclusions

Although some of the measured fuel properties exceed the specification limits in D7566 for hydroprocessed SPK, the handling of these samples beyond the point of origin have likely contributed to the trace contamination. We cannot conclude whether the aromatics in the fuel were present at the point of batch origination or introduced through contamination. While HRJ fuel is not formally part of the D7566 specification, efforts are underway to incorporate those fuels in the next year. It is currently anticipated that no additional specification requirements will be needed to handle HRJ. The D7566 specification for hydroprocessed SPK refers only to sample quality at the point of batch origination and is primarily used to verify that the process is adequately controlled. Once certified to D7566, recertification beyond the point of batch origination must be done according to D1655.

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Appendix E1

Data

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Table E1-1. Results for FT Fuel Analysis

SwRI Sample Code			CL09-00163	CL09-00164	CL09-00268	CL09-00169	CL09-00170	D7566-09
Test	Method	Units	SASOL GTL#2	SASOL GTL#1	SASOL IPK	Syntroleum SPK	Shell SPK	
Carbon/Hydrogen Content	D5291							
Carbon Content		mass%	84.69	84.45	84.58	84.37	84.76	
Hydrogen Content		mass%	15.50	15.40	15.23	15.50	15.69	
Carbon + Hydrogen		mass%	100.2	99.8	99.8	99.9	100.4	99.5 min
Water Content	D6304	mg/kg	32	40	38	22	28	75 max
Nitrogen Content	D4629	mg/kg	2	<1	2	<1	1	2 max
Sulfur Content	D5453	ppm	0.6	0.6	1.5	0.6	0.6	15 max
Elemental Analysis	D7111							
Aluminum			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	0.1 mg/kg max (based on UOP 389)
Barium			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Calcium			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Chromium			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Copper			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Iron			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Lithium			<100ppb	125ppb	<100ppb	107ppb	<100ppb	
Lead			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Magnesium			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Manganese			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Molybdenum			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Nickel			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Potassium			<1ppm	<1ppm	<1	<1ppm	<1ppm	
Sodium			<1ppm	2.6ppm	1.3ppm	2.5ppm	1.4ppm	
Silicon			993ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Silver			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Titanium			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Vanadium			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Zinc			<100ppb	<100ppb	<100ppb	<100ppb	<100ppb	
Hydrogen by NMR	D3701	mass%	15.21	15.51	15.41	15.2	15.47	
Hydrocarbon Types by Mass Spec	D2425							
Paraffins		mass%	92.0	97.4	87.5	91.0	96.0	
Cycloparaffins		mass%	7.7	2.6	11.6	9.0	4.0	15 max
Aromatics		mass%	0.3	0.0	1.0	0.0	0.0	0.5 max

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Table E1-2. Results for HRJ Fuel Analysis

SwRI Sample Code			CL09-00171	CL09-00172	CL09-00173	CL09-00174	D7566-09
Test	Method	Units	08POSF5675	08POSF5673	08POSF5674	08POSF5698	
Carbon/Hydrogen Content	D5291						
Carbon Content		mass%	84.62	84.52	85.01	84.99	
Hydrogen Content		mass%	15.43	15.18	15.31	15.31	
Carbon + Hydrogen		mass%	100.0	99.7	100.3	100.3	99.5 min
Water Content	D6304	mg/kg	53	47	23	21	75 max
Nitrogen Content	D4629	mg/kg	<1	<1	<1	<1	2 max
Sulfur Content	D5453	ppm	0.6	0.6	0.8	0.6	15 max
Elemental Analysis	D7111						
Aluminum			<100ppb	<100ppb	<100ppb	110ppb	0.1 mg/kg max (based on UOP 389)
Barium			<100ppb	<100ppb	<100ppb	<100ppb	
Calcium			<100ppb	<100ppb	<100ppb	<100ppb	
Chromium			<100ppb	<100ppb	<100ppb	<100ppb	
Copper			<100ppb	<100ppb	<100ppb	<100ppb	
Iron			<100ppb	<100ppb	<100ppb	<100ppb	
Lithium			<100ppb	<100ppb	<100ppb	<100ppb	
Lead			<100ppb	<100ppb	<100ppb	<100ppb	
Magnesium			<100ppb	<100ppb	<100ppb	<100ppb	
Manganese			<100ppb	<100ppb	<100ppb	<100ppb	
Molybdenum			<100ppb	<100ppb	<100ppb	<100ppb	
Nickel			<100ppb	<100ppb	<100ppb	<100ppb	
Potassium			<1ppm	<1ppm	<1ppm	<1ppm	
Sodium			1.6ppm	1.4ppm	2.0ppm	2.3ppm	
Silicon			<100ppb	<100ppb	<100ppb	<100ppb	
Silver			<100ppb	<100ppb	<100ppb	<100ppb	
Titanium			<100ppb	<100ppb	<100ppb	<100ppb	
Vanadium			<100ppb	<100ppb	<100ppb	<100ppb	
Zinc			<100ppb	<100ppb	<100ppb	<100ppb	
Hydrogen by NMR	D3701	mass%	15.43	15.31	15.23	14.97	
Hydrocarbon Types by Mass Spec	D2425						
Paraffins		mass%	96.1	94.8	85.8	89.8	
Cycloparaffins		mass%	3.9	5.2	14.2	9.0	15 max
Aromatics		mass%	0.0	0.0	0.0	1.2	0.5 max

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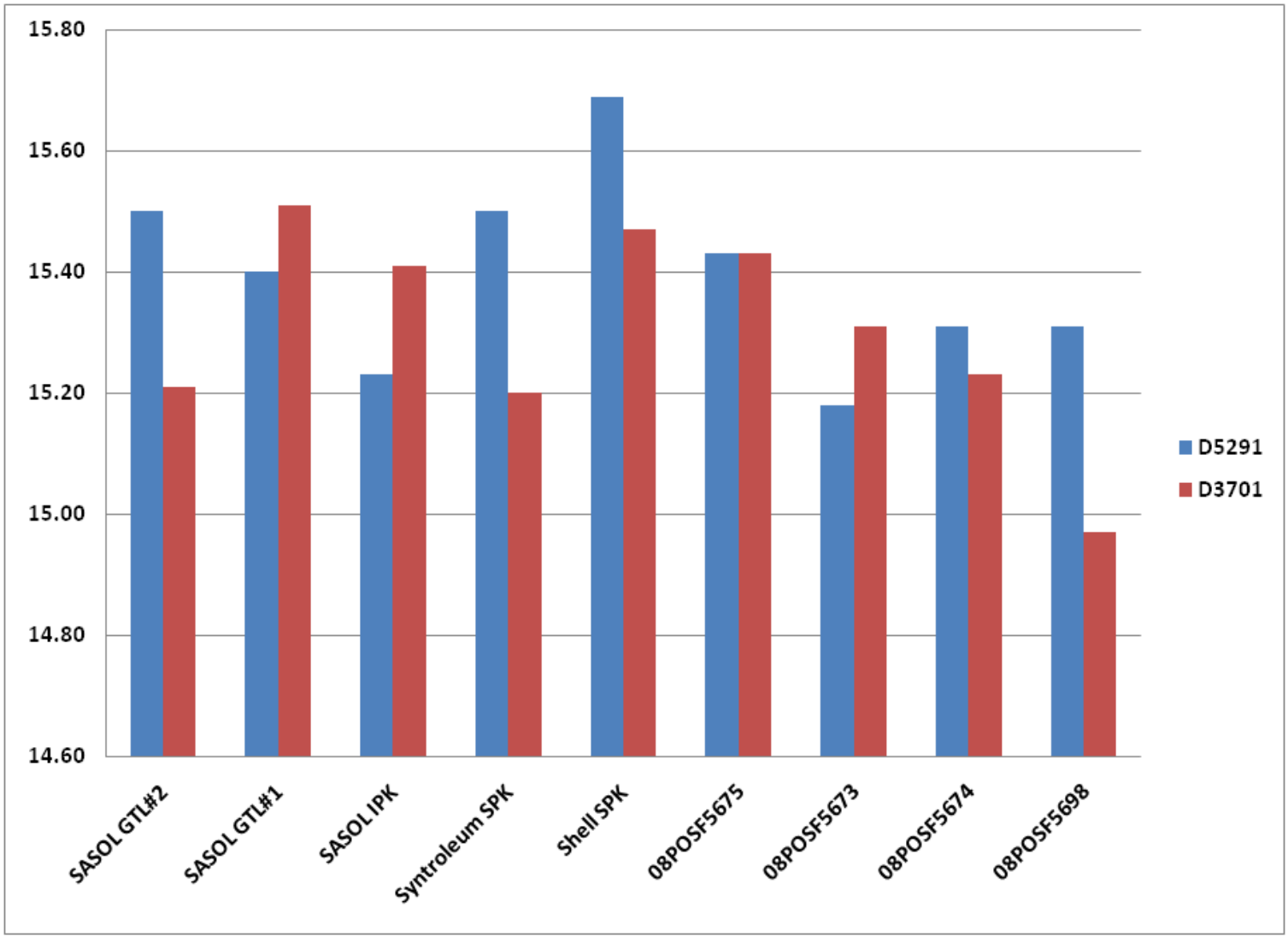

Figure E1-1. Hydrogen Content (mass%)

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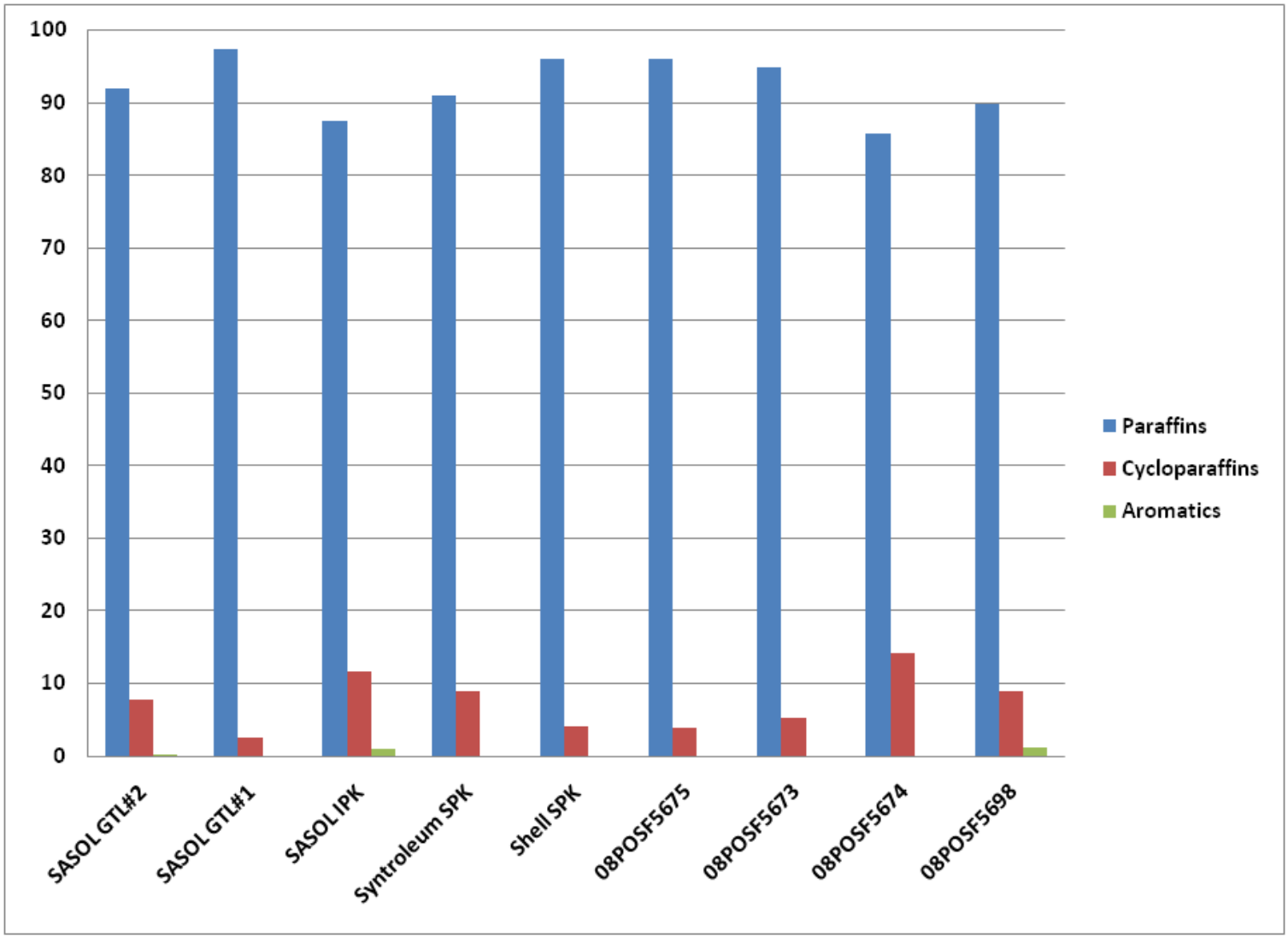

Figure E1-2. Hydrocarbon Types (mass%)

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Appendix F

Dielectric Constant Report

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DIELECTRIC CONSTANTS OF SYNTHETIC JET FUEL

FINAL REPORT
SwRI® Project No. 08-14406.02

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Foreword / Acknowledgements

Southwest Research Institute (SwRI) would like to thank Goodrich Sensors and Integrated Systems-VT for the loan of their k-cell for performing the dielectric measurements in this study.

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1.0 Objective

The objective of this effort was to determine if emerging synthetic paraffinic kerosenes (SPK), such as Sasol IPK, have dielectric constants in the same range as current petroleum-based aviation fuels, such as Jet A.

2.0 Background

The dielectric constant of a fuel is calculated by dividing the capacitance of the fuel by the capacitance of air. The dielectric constant is a linear function of temperature decreasing with increasing temperature. Since the density of the fuel is also a linear function of temperature that varies inversely, the dielectric constant increases as density increases.

Aircraft fuel gauging systems utilize capacitance probes located in each fuel tank. The fuel level is measured as a change in capacitance as fuel displaces the air inside the tubular fuel probe. Since the electrical properties of fuels can vary from type to type and even among different batches of the same fuel, compensators are used to provide the gauging system with a point of reference and adjust for changes in density (and therefore dielectric constant) as a function of temperature. Compensators are located at the lowest point in an aircraft fuel tank.

3.0 Approach

The capacitance cell (k-cell) used for this work was provided under a bailment agreement by Goodrich Sensors and Integrated Systems-VT. An Andeen-Hagerling ultra precision capacitance bridge (AH 2700A, 50Hz-20kHz) was used to make the capacitance measurements. All capacitance measurements were collected at 400Hz since most of the historical data was collected at that frequency. Recent discussions suggest that a higher frequency should be considered (e.g. $\geq$ 1 kHz) to negate the affect of entrained water and perhaps to coincide with the higher frequencies at which current aircraft operate.

The dielectric measurements were conducted according to guidance provided by Goodrich. In general, the experimental procedure was as follows:

- Measure the capacitance of air using a clean, dry k-cell
- Submerge the k-cell in fuel
- Allow the fuel and cell to equilibrate to the test temperature
- Record the fuel capacitance and temperature
- Calculate the dielectric constant

The procedure for testing at temperatures other than ambient was less well defined. Our approach was to measure the capacitance of fuel at the desired temperature and divide that by the capacitance of air at ambient temperature. The fuel and k-cell were equilibrated to the test temperature separately, then brought together and the capacitance measured. This was done to reduce the exposure time of the k-cell to the fuel when long equilibration times were necessary.

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4.0 Samples

Eleven fuel samples, identified in Table F-1, were selected for analysis. Two of the existing fuels, Sasol IPK and R-8, were also additized with Static Dissipator Additive (SDA) to determine the effect, if any, of the SDA on the dielectric constant.

Table F-1. Samples

SwRI Sample No.	SwRI Alternate Sample No.	Description	Table	Figure
CL09-00372	AL 27915	POSF4751 (JP-8)	Table F1-1	Figure F2-1
CL09-00373	AL 27892	AL-27892 (Shell SPK)	Table F1-2	Figure F2-2
CL09-00374	AL 27074	S-8 (probably POSF5018)	Table F1-3	Figure F2-3
CL09-00375	AL-27940 (also AL-27990)	50 / 50 Shell / JP-8	Table F1-4	Figure F2-4
CL09-00376	AL-27916	POSF5171 (50 / 50 S-8 / JP-8)	Table F1-5	Figure F2-5
CL09-00268	AF-6924 (also AL-28518)	POSF5642 (Sasol IPK)	Table F1-6	Figure F2-6
CL09-00324	AF-6778	R-8 (lot-1)	Table F1-7	Figure F2-7
CL09-00848		Sasol IPK w/ SDA (3 ppm)	Table F1-8	Figure F2-8
CL09-00847		R-8 w/ SDA (3 ppm)	Table F1-9	Figure F2-9
CL09-00342	AL-28621	POSF4658 (Jet A)	Table F1-10	Figure F2-10
CL09-00343	AL-28622	POSF5706 (S-8 / Jet A)	Table F1-11	Figure F2-11

5.0 Analysis

For each sample, the dielectric constant and the density as a function of temperature was measured. The raw measurements can be found in Appendix F1 as indicated in the sample table (Table F-1). Dielectric Constant vs. Density plots were then generated from this data (Figures in Appendix F2). The density values for each dielectric constant measurement were determined by extrapolating from the density data for each sample (Table F1-12).

The fuels in this study cover a range of densities between 0.68-0.85 g/mL. Nominal densities at 15°C are shown in Figure F-1. A plot of Dielectric Constant vs. Density for all samples, (Figure F-2) shows the expected linear trend. Figure F-3 identifies each of the samples showing that the petroleum-based samples lie at the high end of the dielectric constant range while the neat synthetic fuels lie at the low end. The samples cover a dielectric constant range of approximately 1.92 - 2.20.

In Figure F-4, the dielectric constant is plotted as a function of temperature for each sample. An overlay of the CRC data supports these results for the petroleum-based fuels. It also indicates that the neat fuels and their blends are distinctly different but fall in a narrow range of dielectric constant values.

The SDA-additized samples of Sasol IPK and R-8 show slight differences to their unadditized equivalents. The differences appear insignificant and may be equally attributable to slight temperature variations during the measurement.

For a general comparison, nominal dielectric constants at 15°C are plotted in Figure F-5.

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5.1 Effect of Frequency on Dielectric Constant

Discussions with Boeing revealed that the use of the 400 Hz sampling frequency was used by the Fuel Quantity Indicating System (FQIS) long ago but modern systems operate at much higher frequencies. Current operating frequencies may range from approximately 3-20 kHz. Operating below 1 kHz may be an issue if water is present (change in fuel conductivity) or if fringing effects exist. For that reason, we measured the dielectric constant of a selected fuel at several frequencies. The fuel chosen was the neat Sasol IPK and it was measured at frequencies ranging from 400-12,000 Hz at ambient temperature (Table F-2). For this particular neat, dry fuel the results indicate that there is little difference (~0.02%) over that range of frequencies.

Table F-2. Dielectric Constant vs. Frequency

Frequency (Hz)	Dielectric Constant*
400	2.0008
1000	2.0007
2000	2.0006
4000	2.0006
8000	2.0010
12000	2.0012

*ambient temperature

6.0 Summary

A comparison of dielectric constants for petroleum-based fuels, synthetic fuels, and their blends revealed distinct differences. The dielectric constants of the synthetic fuels respond linearly to changes in density like their petroleum-based counterparts but have lower values. Although the differences appear to be relatively small, we don't have sufficient information on the FQIS to judge whether those differences can be adequately compensated for in the aircraft tank gauging system.

Although testing showed no significant effect of frequency on dielectric constant, this test was performed under ideal conditions on a single fuel only. To be consistent with other labs, future work at SwRI will be performed at higher frequencies (~10 kHz).

7.0 Recommendations

Having gained some experience with the k-cell, there are several aspects of this procedure that should be considered if a standardized procedure is to be developed.

- The air background is certainly a source of variation. Humidity and temperature will likely affect the results. Placing the k-cell in an enclosure that is purged with dry air and temperature controlled (e.g. 25°C), may be one approach to standardizing the air background.

- Temperature control is very important since the dielectric constant is a function of fuel density. The ability to control the temperature to within 0.1°C can be difficult across the range of temperatures used in this study (-40°C to 80°C) but should be considered. Since these results show that the dielectric/density relationship is very linear, several measurements over a reduced temperature range might be adequate to generate a curve for extrapolation.

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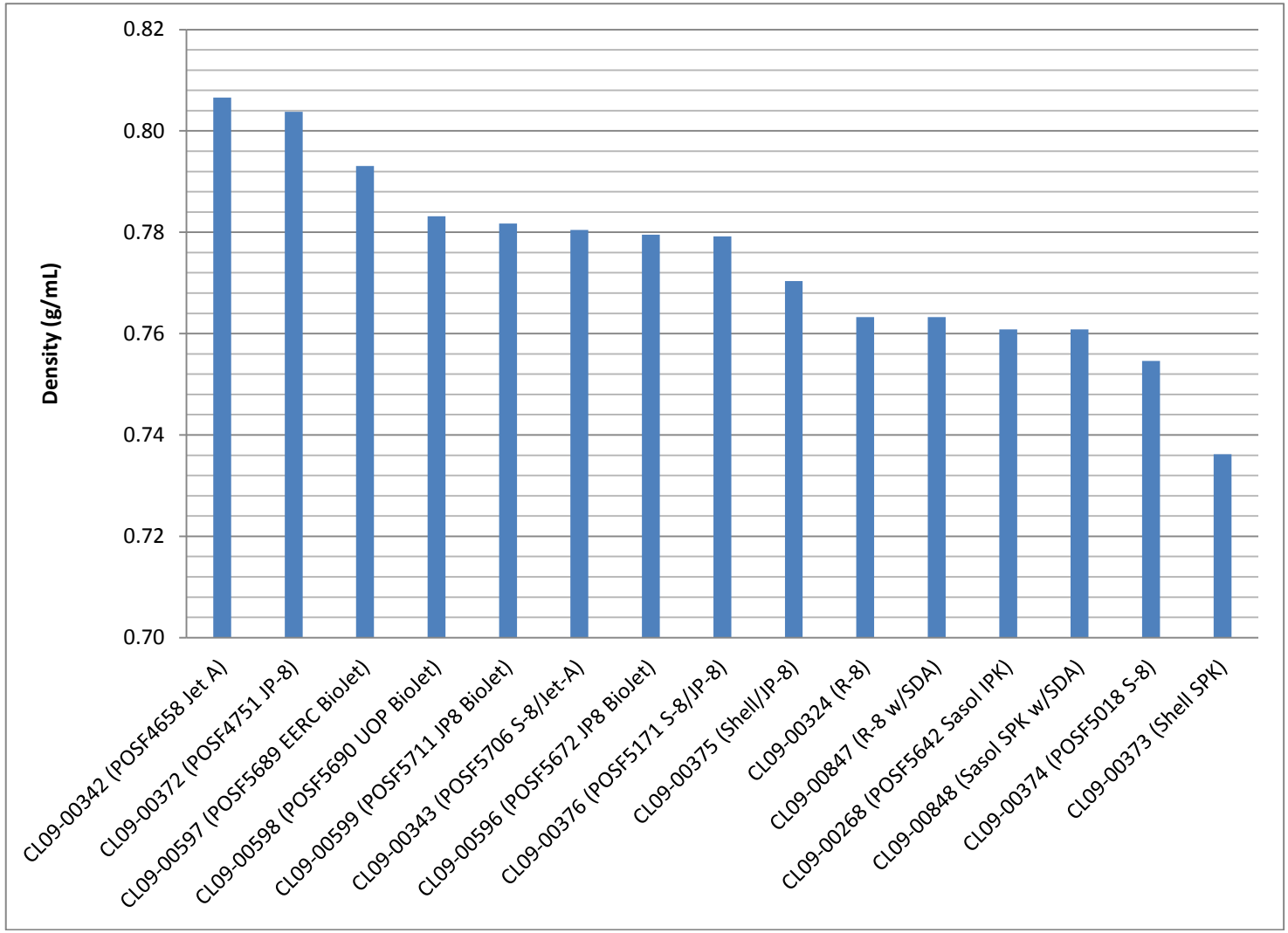

Figure F-1. Sample Density (at 15°C)

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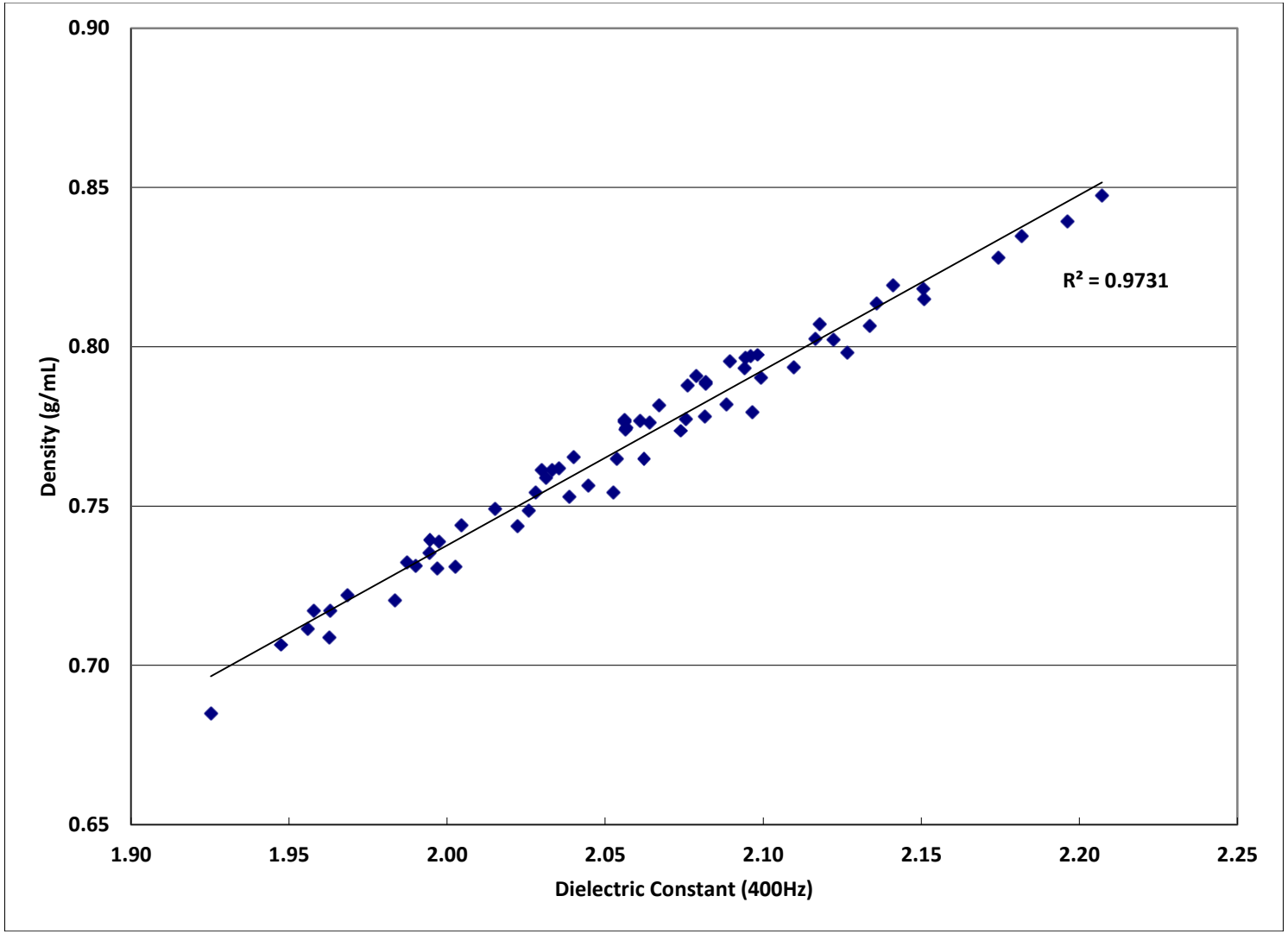

Figure F-2. Dielectric Constant (400Hz) vs. Density (All Samples)

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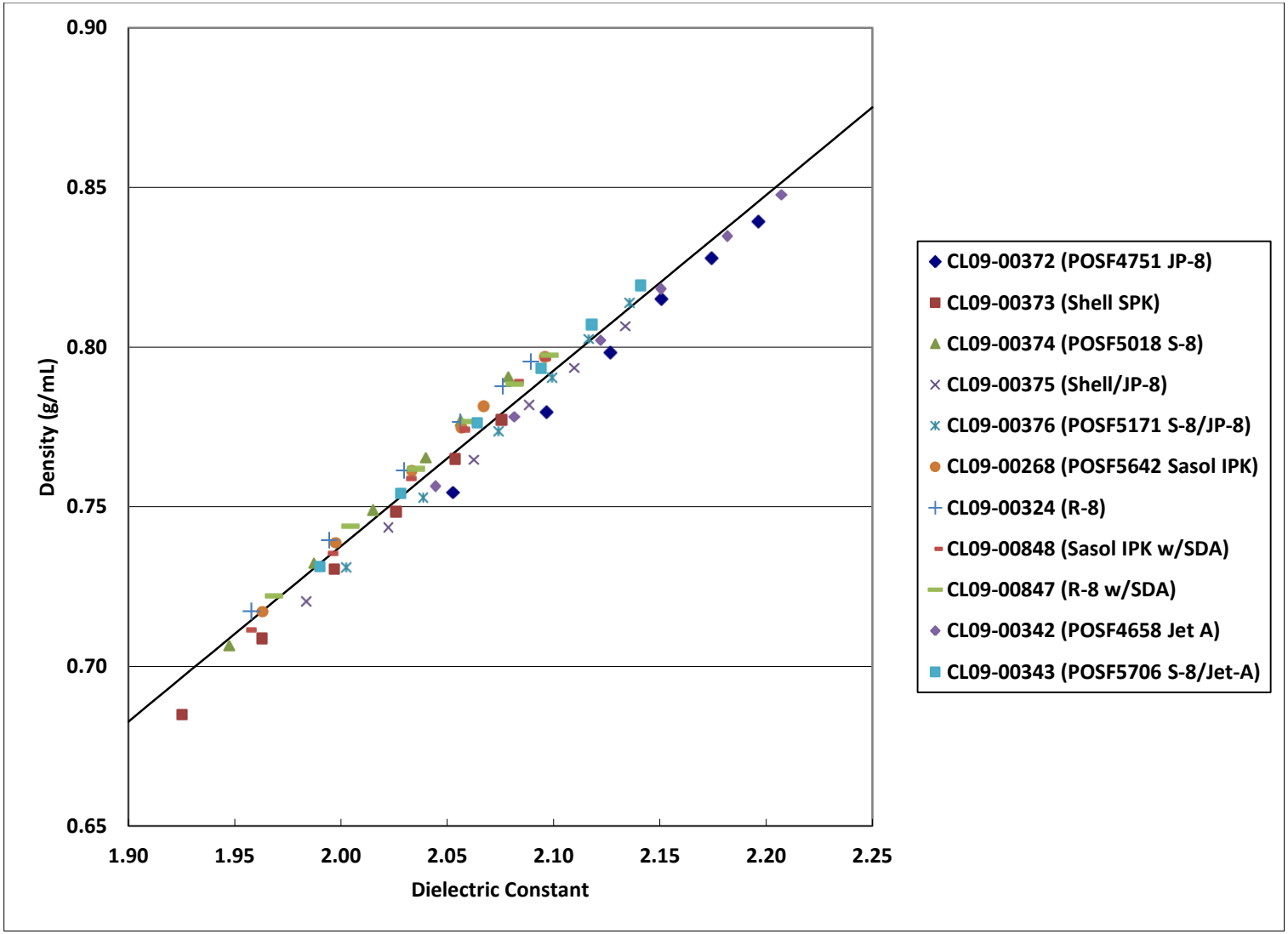

Figure F-3. Dielectric Constant (400Hz) vs. Density (with samples identified)

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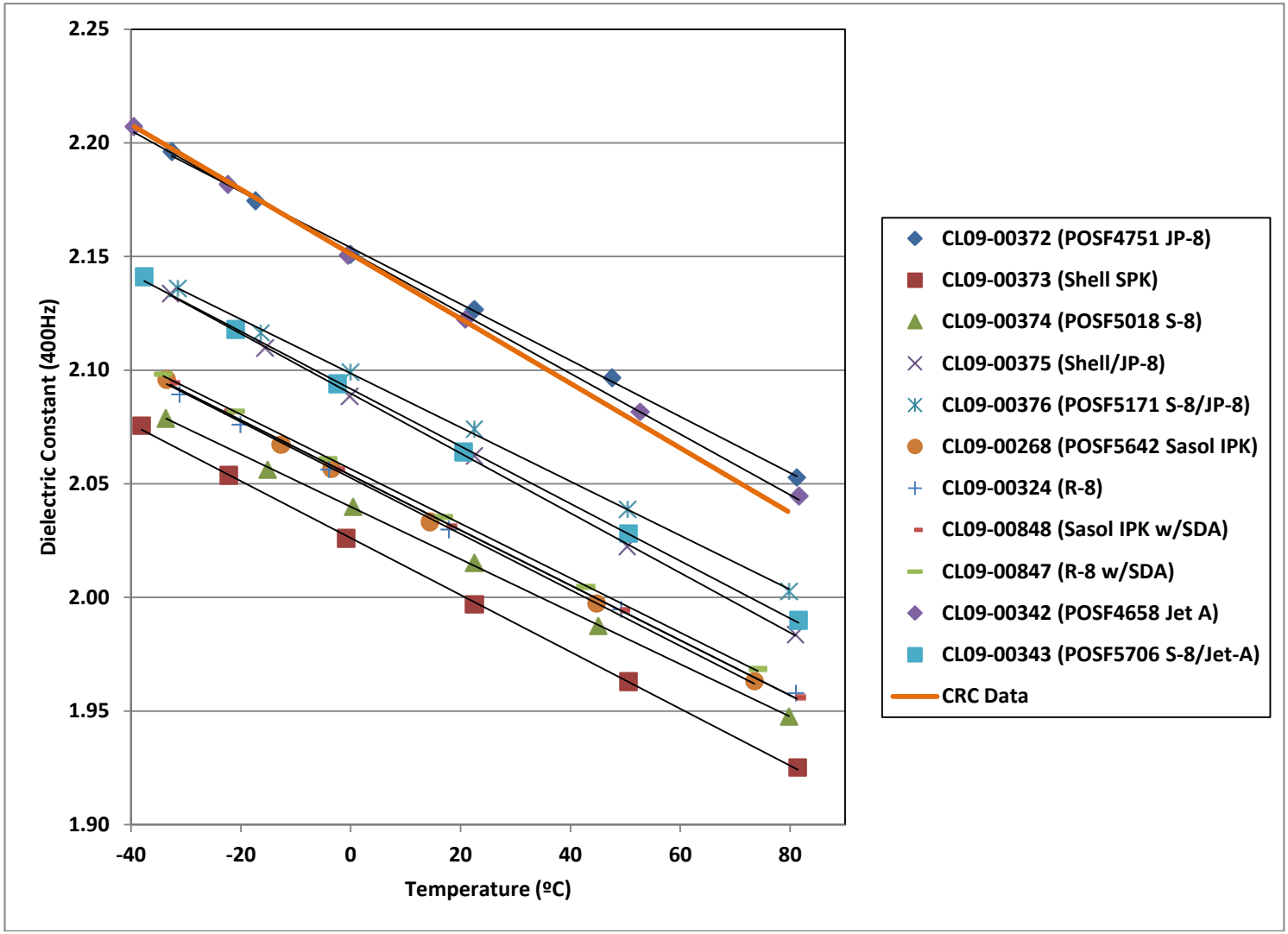

Figure F-4. Dielectric Constant (400Hz) vs. Temperature (with CRC overlay)

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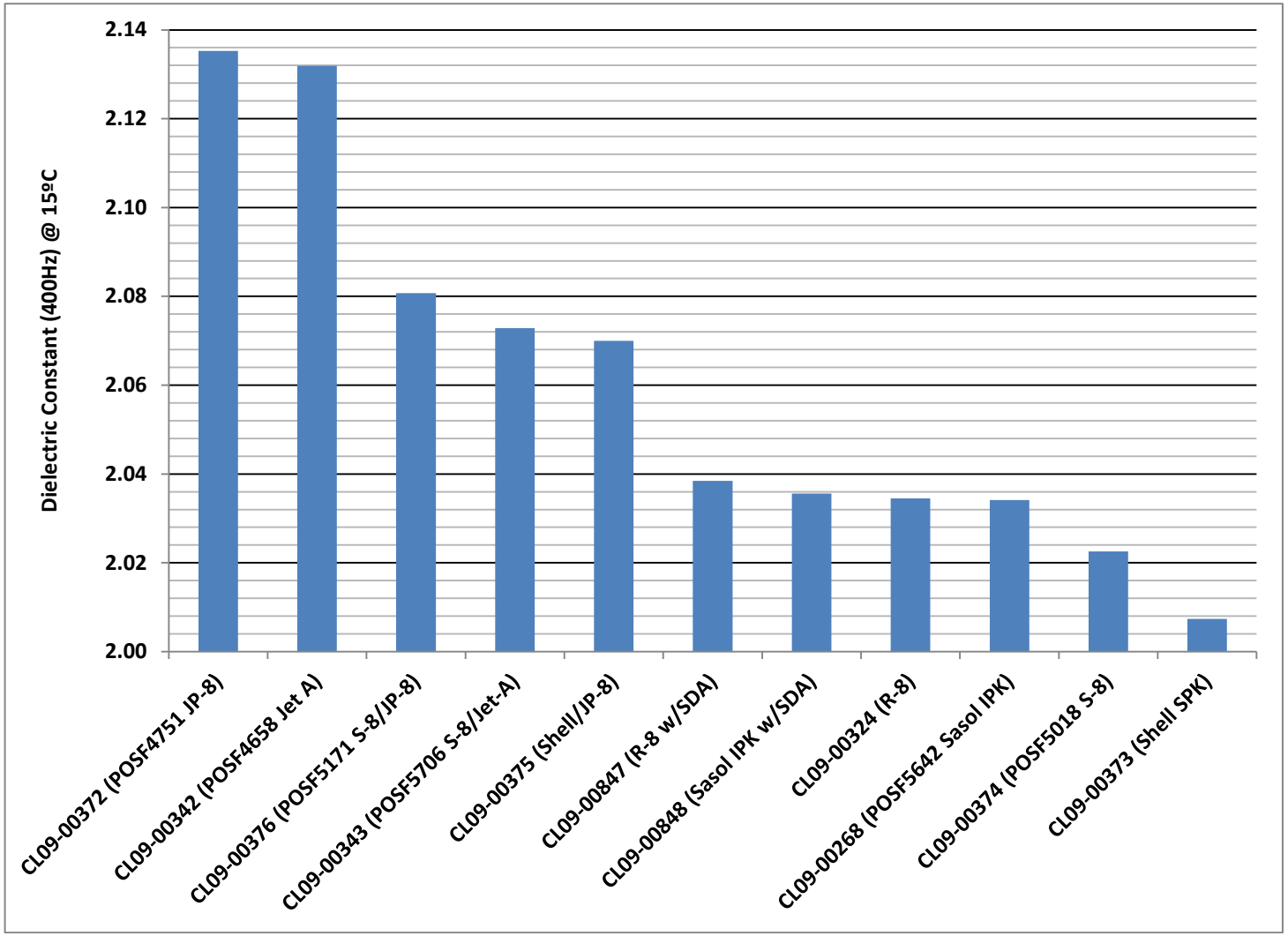

Figure F-5. Nominal Dielectric Constant (400Hz) @15°C

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Appendix F1

Data

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Table F1-1. CL09-00372 - POSF4751 (JP8).

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-32.6	2.1963
-17.4	2.1745
0.0	2.1509
22.5	2.1267
47.6	2.0967
81.2	2.0527
Density (D4052), g/mL	
0	0.8152
15	0.8035
40	0.7852
60	0.7702
80	0.7554

Table F1-2. CL09-00373 - Shell SPK.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-38.1	2.0755
-22.2	2.0538
-0.9	2.0259
22.5	1.9969
50.6	1.9628
81.4	1.9252
Density (D4052), g/mL	
0	0.7478
15	0.7361
40	0.7170
60	0.7015
80	0.6860

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Table F1-3. CL09-00374 - POSF5018 (S-8).

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-33.6	2.0788
-15.1	2.0562
0.5	2.0399
22.5	2.0151
45.1	1.9874
79.8	1.9475
Density (D4052), g/mL	
0	0.7659
15	0.7544
40	0.7361
60	0.7211
80	0.7064

Table F1-4. CL09-00375 - 50/50 Shell SPK / JP-8.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-32.8	2.1337
-15.6	2.1096
-0.2	2.0884
22.5	2.0623
50.3	2.0223
81.0	1.9836
Density (D4052), g/mL	
0	0.7818
15	0.7702
40	0.7515
60	0.7363
80	0.7211

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Table F1-5. CL09-00376 - POSF5171 - 50/50 S-8 / JP-8.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-31.5	2.1359
-16.4	2.1164
0.0	2.0992
22.5	2.0740
50.4	2.0387
79.8	2.0026
Density (D4052), g/mL	
0	0.7905
15	0.7790
40	0.7607
60	0.7457
80	0.7310

Table F1-6. CL09-00268 - POSF5642 - Sasol IPK.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-33.5	2.0959
-12.7	2.0671
-3.5	2.0568
14.4	2.0332
44.7	1.9974
73.5	1.9631
Density (D4052), g/mL	
0	0.7719
15	0.7609
40	0.7422
60	0.7276
80	0.7121

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Table F1-7. CL09-00324 - R-8 Lot 1.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-31.2	2.0894
-20.1	2.0760
-4.0	2.0562
17.9	2.0299
49.2	1.9946
81	1.9578
Density (D4052), g/mL	
0	0.7742
15	0.7632
40	0.7449
60	0.7322
80	0.7182

Table F1-8. CL09-00848 - Sasol IPK w/ SDA.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-32.8	2.0943
-22.9	2.0818
-2.8	2.0564
17.7	2.0313
49.2	1.9943
81.2	1.9559
Density (D4052), g/mL	
0	0.7719
15	0.7609
40	0.7422
60	0.7276
80	0.7121

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Table F1-9. CL09-00847 - R-8 w/ SDA.

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-34.1	2.0982
-21	2.0818
-4.2	2.0609
16.9	2.0353
42.8	2.0046
74.1	1.9684
Density (D4052), g/mL	
0	0.7742
15	0.7632
40	0.7449
60	0.7322
80	0.7182

Table F1-10. CL09-00342 - POSF4658 (Jet A).

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-39.5	2.2072
-22.4	2.1817
-0.5	2.1506
20.8	2.1222
52.7	2.0816
81.6	2.0446
Density (D4052), g/mL	
0	0.8179
15	0.8061
40	0.7881
60	0.7732
80	0.7571

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Table F1-11. CL09-00343 - POSF5706 (S-8 / Jet A).

Test / Temperature (°C)	Value
Dielectric Constant (400Hz)	
-37.6	2.141
-21	2.118
-2.4	2.094
20.6	2.064
50.5	2.028
81.5	1.990
Density (D4052), g/mL	
0	0.7916
15	0.7804
40	0.7620
60	0.7472
80	0.7324

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Table F1-12. Dielectric Constant and Extrapolated Density.

Sample ID	Temperature (°C)	Dielectric Constant (400Hz)	Density (g/mL)
CL09-00372	-32.6	2.1963	0.8393
	-17.4	2.1745	0.8279
	0	2.1509	0.8150
	22.5	2.1267	0.7982
	47.6	2.0967	0.7795
	81.2	2.0527	0.7544
CL09-00373	-38.1	2.0755	0.7772
	-22.2	2.0538	0.7649
	-0.9	2.0259	0.7485
	22.5	1.9969	0.7304
	50.6	1.9628	0.7087
	81.4	1.9252	0.6850
CL09-00374	-33.6	2.0788	0.7907
	-15.1	2.0562	0.7770
	0.5	2.0399	0.7654
	22.5	2.0151	0.7490
	45.1	1.9874	0.7322
	79.8	1.9475	0.7065
CL09-00375	-32.8	2.1337	0.8066
	-15.6	2.1096	0.7935
	-0.2	2.0884	0.7819
	22.5	2.0623	0.7647
	50.3	2.0223	0.7436
	81	1.9836	0.7204
CL09-00376	-31.5	2.1359	0.8137
	-16.4	2.1164	0.8025
	0	2.0992	0.7903
	22.5	2.0740	0.7736
	50.4	2.0387	0.7529
	79.8	2.0026	0.7311
CL09-00268	-33.5	2.0959	0.7970
	-12.7	2.0671	0.7815
	-3.5	2.0568	0.7746
	14.4	2.0332	0.7613
	44.7	1.9974	0.7387
	73.5	1.9631	0.7172
CL09-00324	-31.2	2.0894	0.7955
	-20.1	2.0760	0.7878
	-4	2.0562	0.7765
	17.9	2.0299	0.7613
	49.2	1.9946	0.7394
	81	1.9578	0.7172
CL09-00848	-32.8	2.0943	0.7965
	-22.9	2.0818	0.7891
	-2.8	2.0564	0.7741

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Table F1-12. Dielectric Constant and Extrapolated Density.

Sample ID	Temperature (°C)	Dielectric Constant (400Hz)	Density (g/mL)
	17.7	2.0313	0.7588
	49.2	1.9943	0.7353
	81.2	1.9559	0.7115
CL09-00847	-34.1	2.0982	0.7975
	-21	2.0818	0.7884
	-4.2	2.0609	0.7767
	16.9	2.0353	0.7620
	42.8	2.0046	0.7439
	74.1	1.9684	0.7221
CL09-00342	-39.5	2.2072	0.8476
	-22.4	2.1817	0.8347
	-0.5	2.1506	0.8182
	20.8	2.1222	0.8022
	52.7	2.0816	0.7782
	81.6	2.0446	0.7564
CL09-00343	-37.6	2.1410	0.8194
	-21	2.1180	0.8071
	-2.4	2.0940	0.7933
	20.6	2.0640	0.7763
	50.5	2.0280	0.7542
	81.5	1.9900	0.7313

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Appendix F2

Figures

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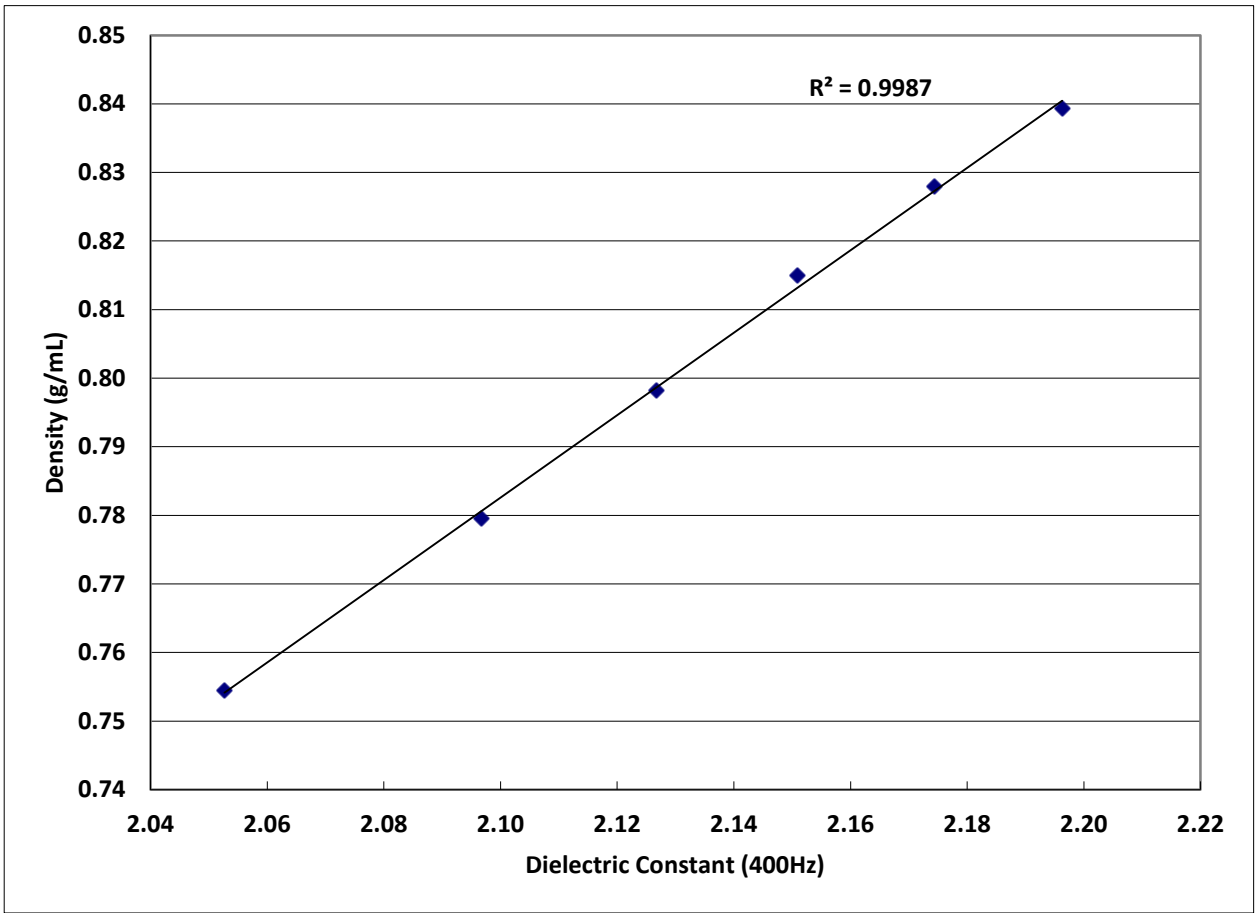

Figure F2-1. CL09-00372 (POSF4751 JP8)

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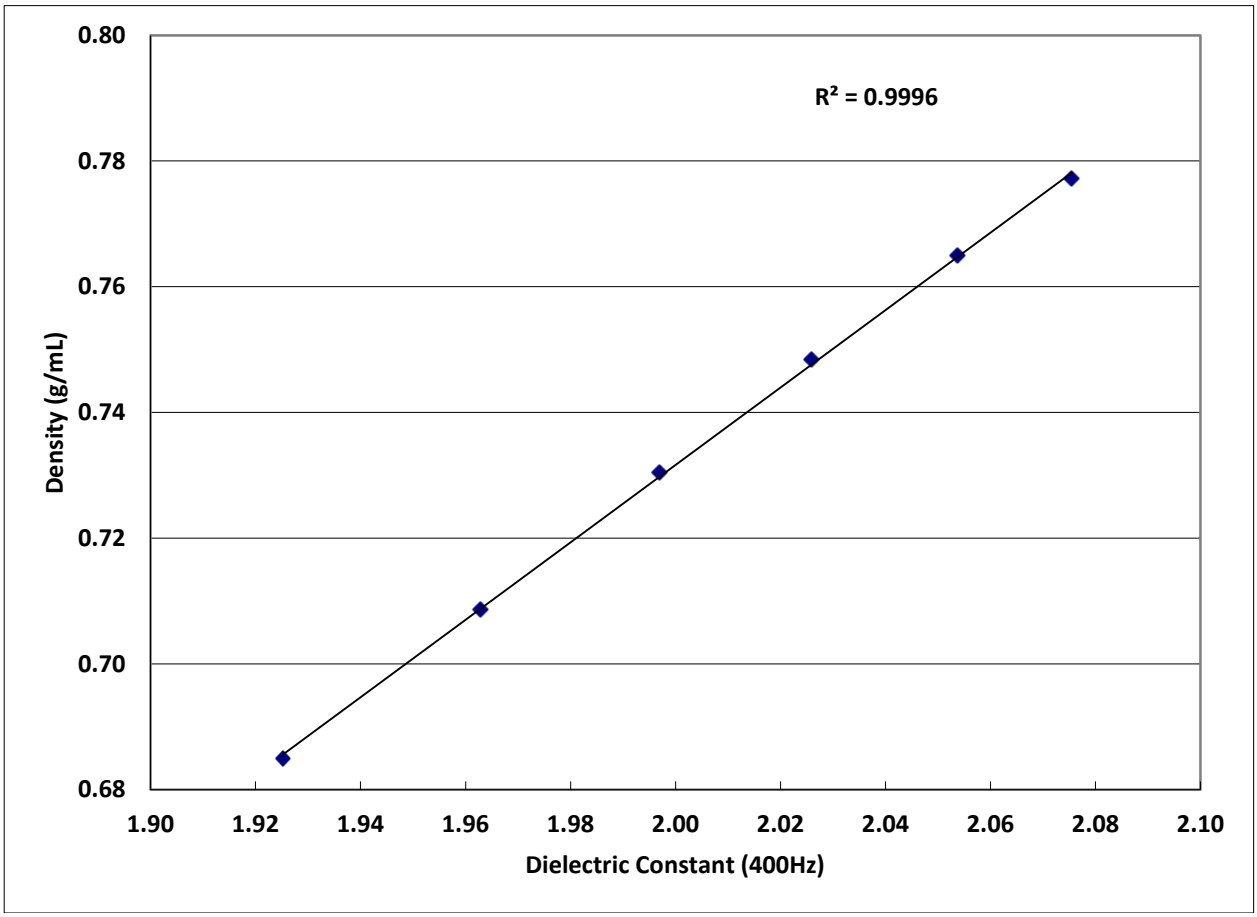

Figure F2-2. CL09-00373 (Shell SPK)

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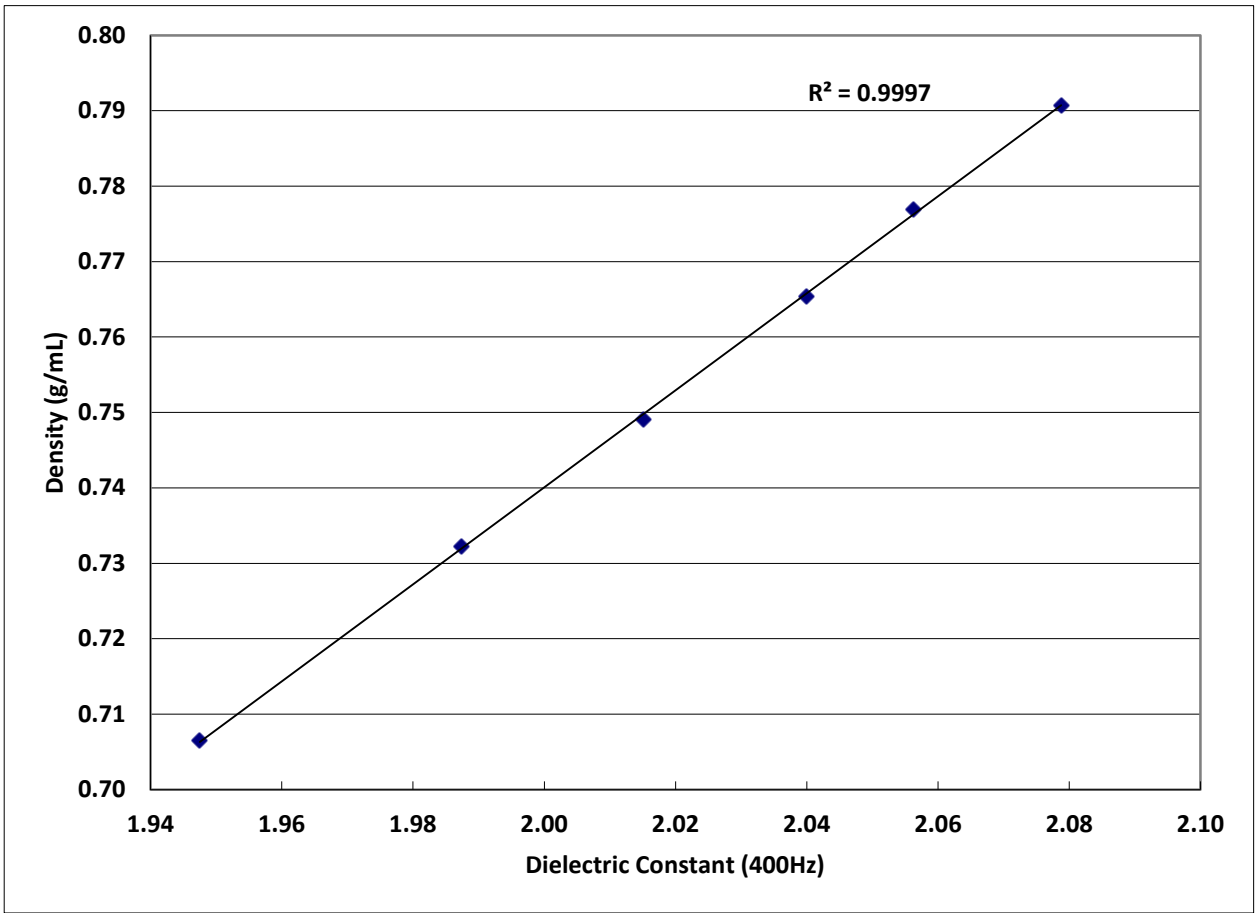

Figure F2-3. CL09-00374 (POSF5018 S-8)

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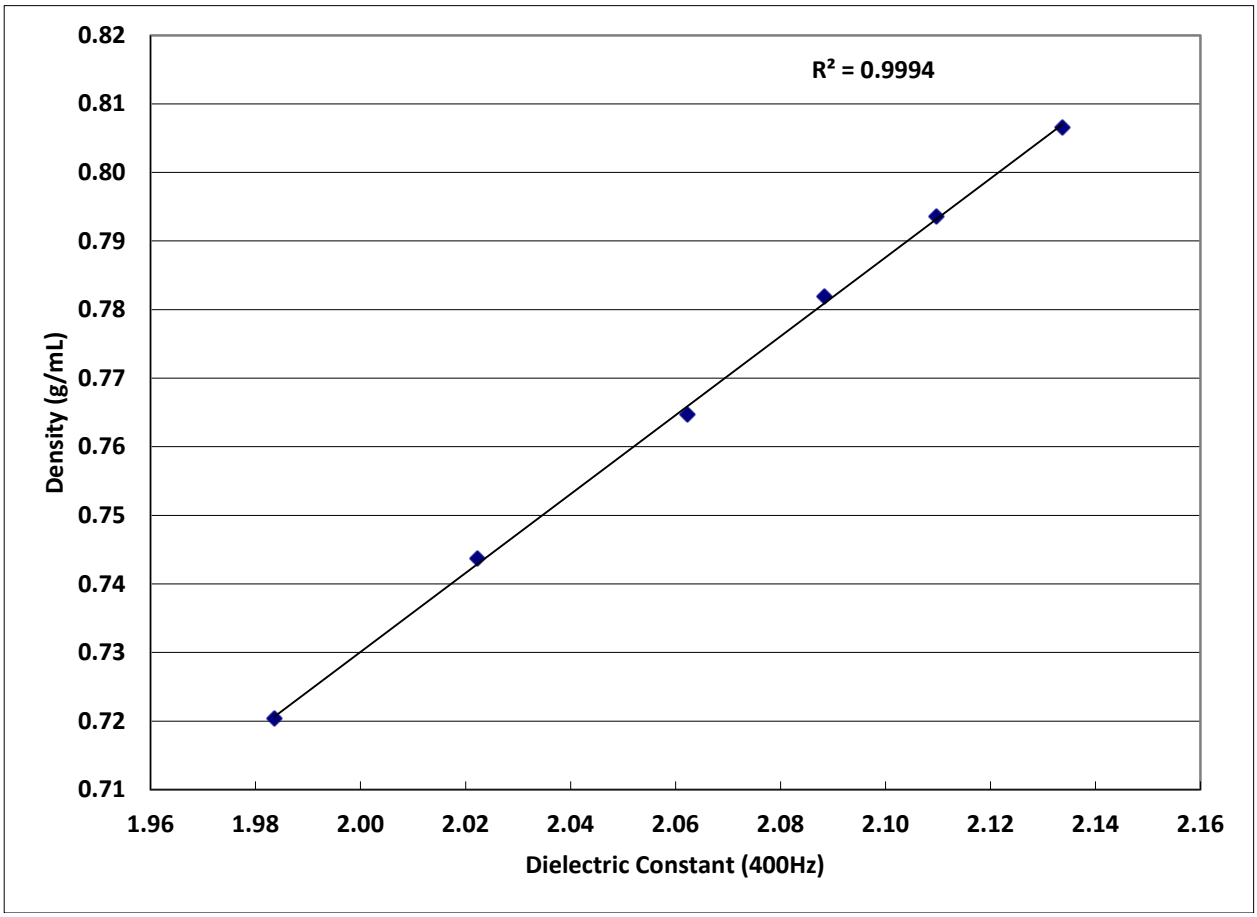

Figure F2-4. CL09-00375 (50/50 Shell SPK / JP-8)

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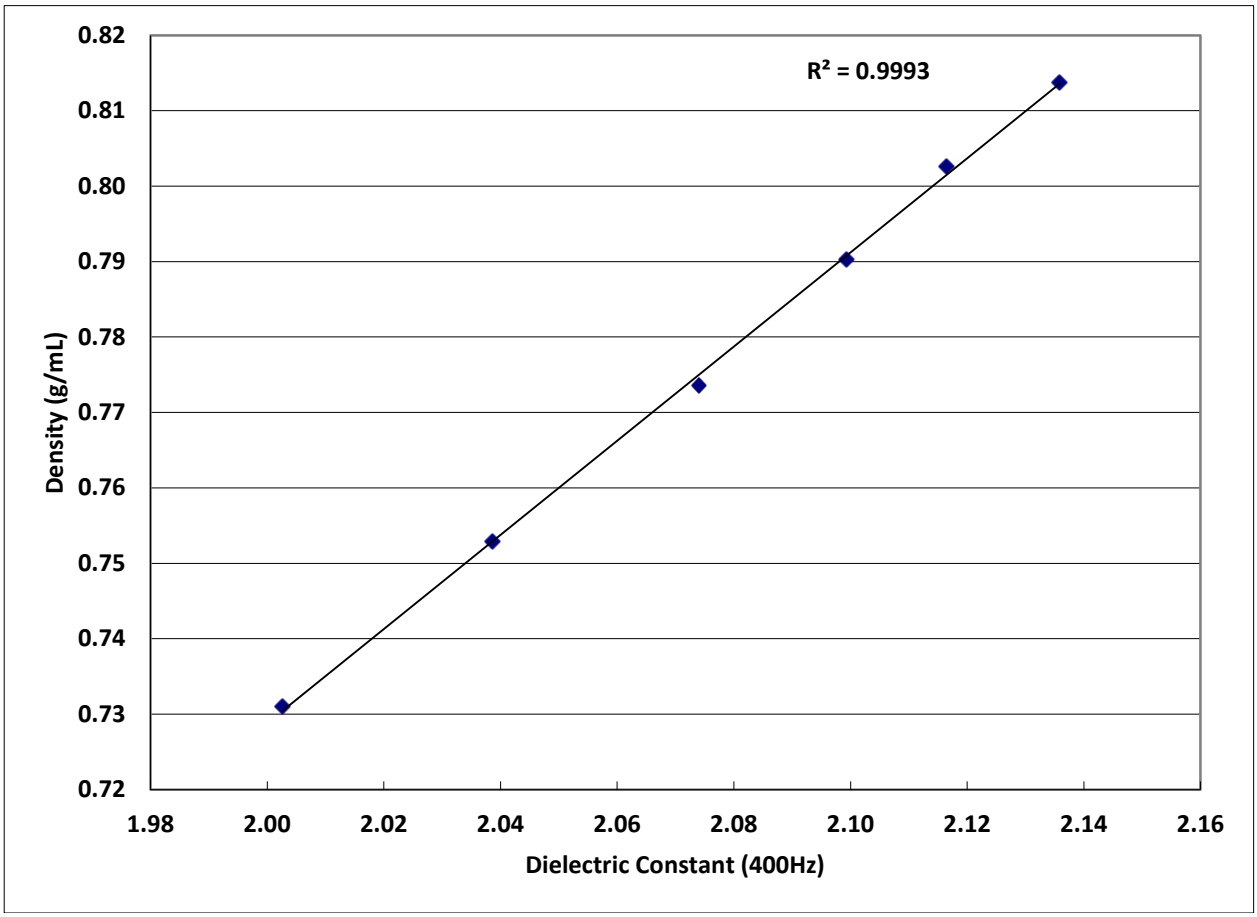

Figure F2-5. CL09-00376 (POSF5171 50/50 S-8 / JP-8)

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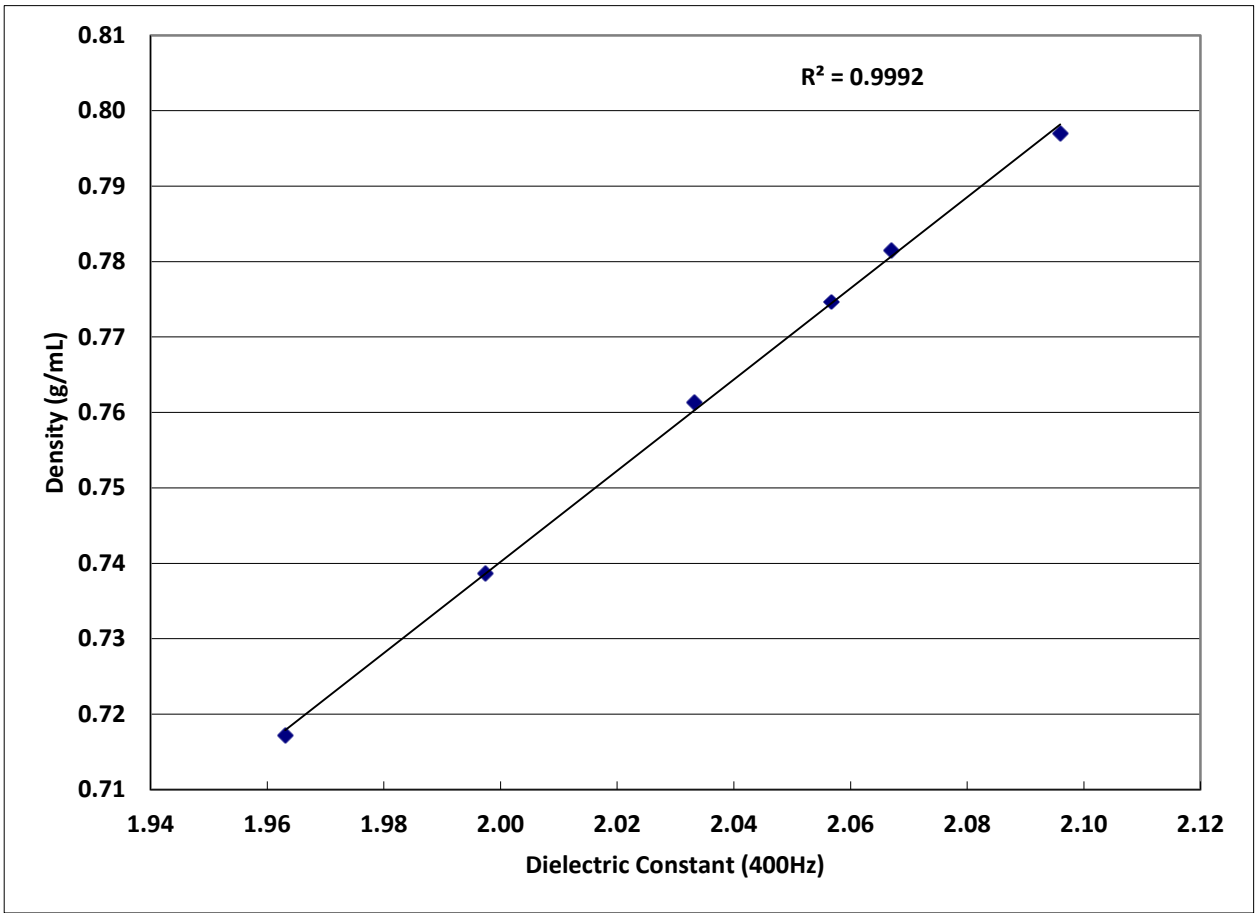

Figure F2-6. CL09-00268 (POSF5642 Sasol IPK)

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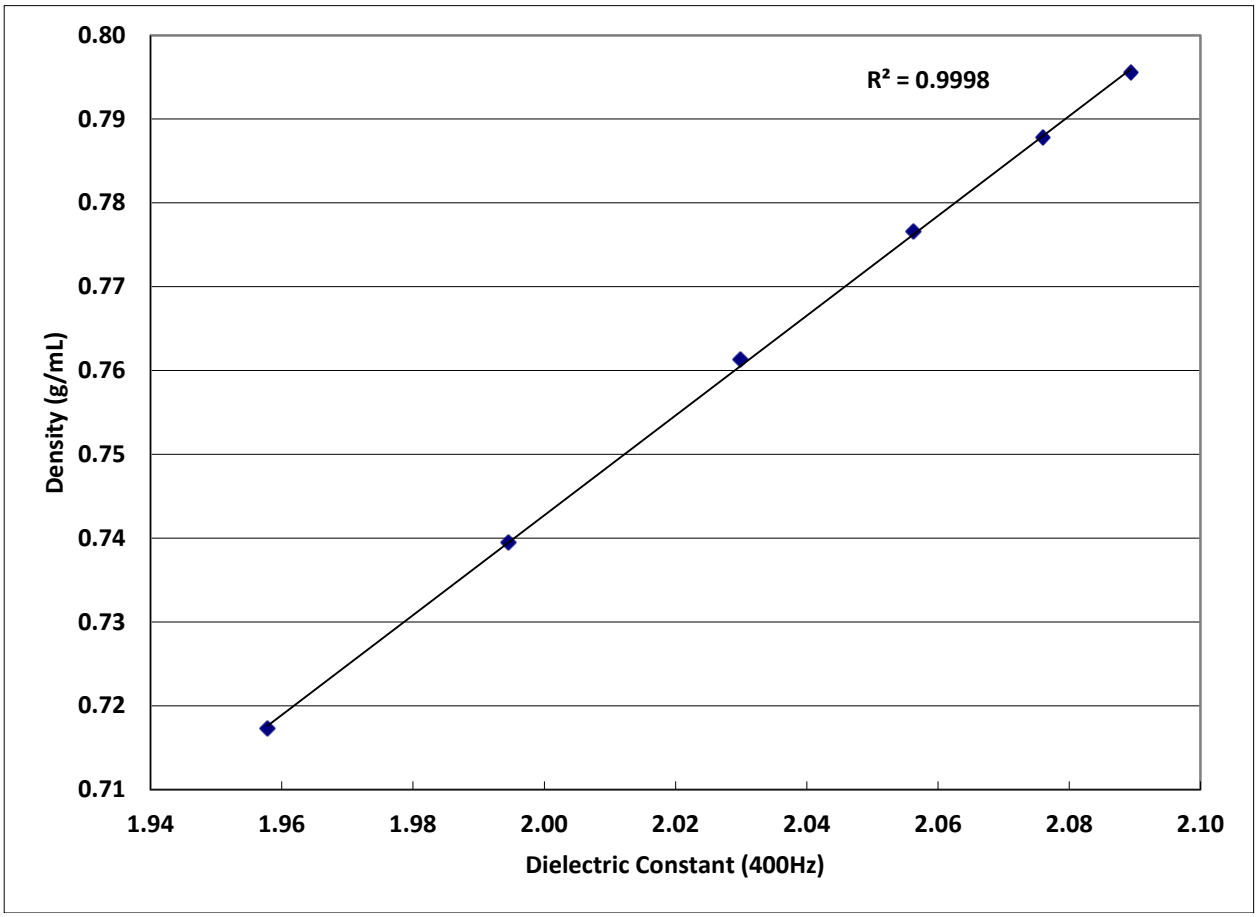

Figure F2-7. CL09-00324 (R-8 Lot 1)

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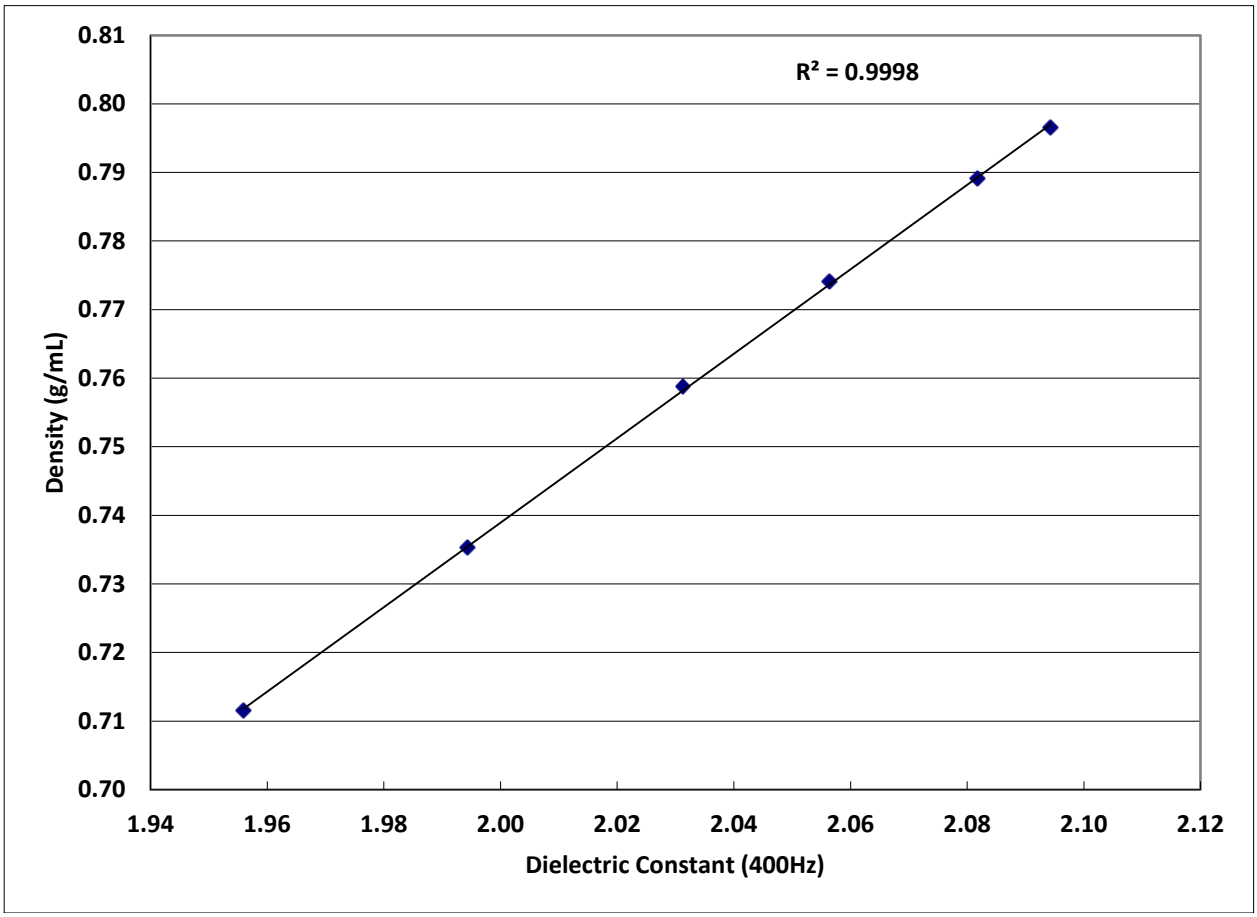

Figure F2-8. CL09-00848 (Sasol IPK w/ SDA)

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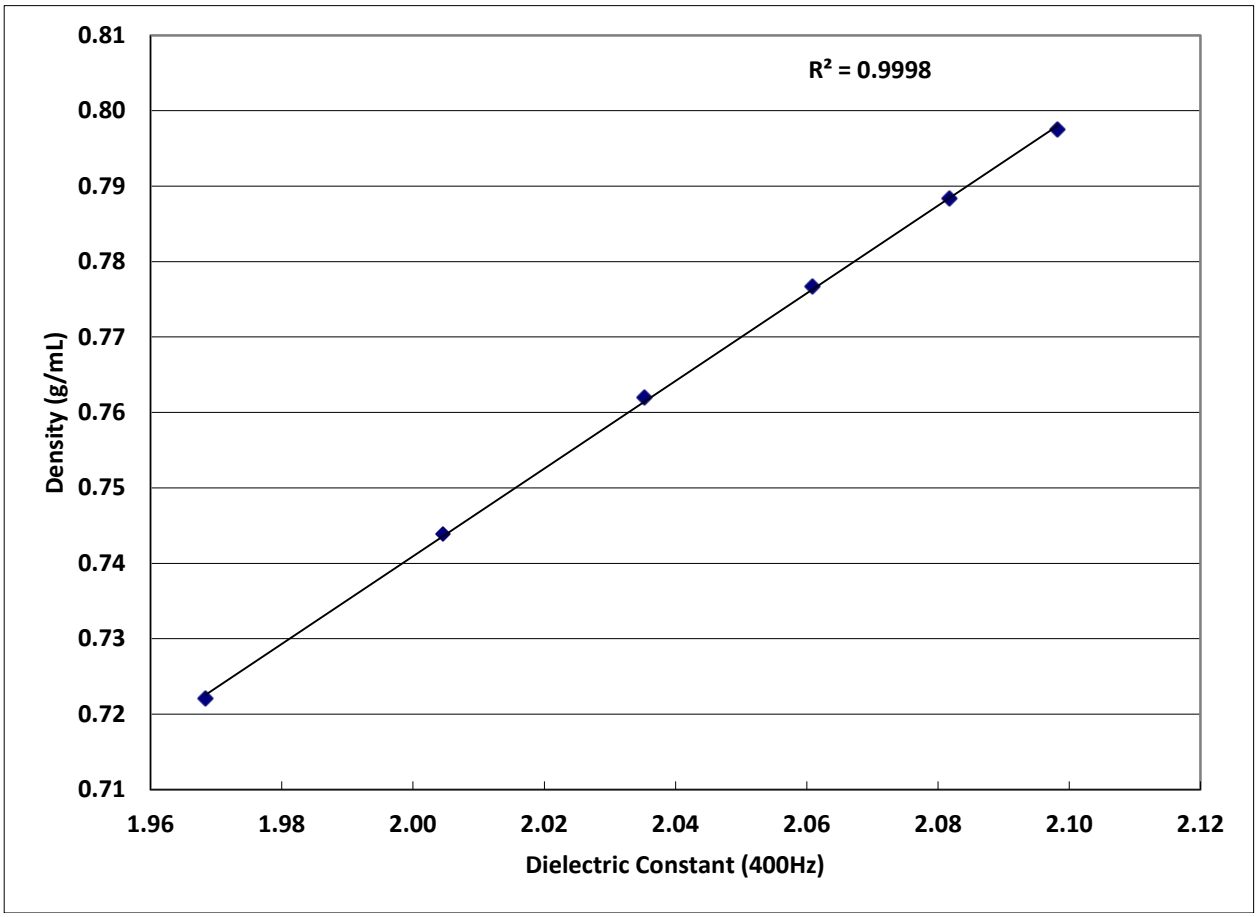

Figure F2-9. CL09-00847 (R-8 w/ SDA)

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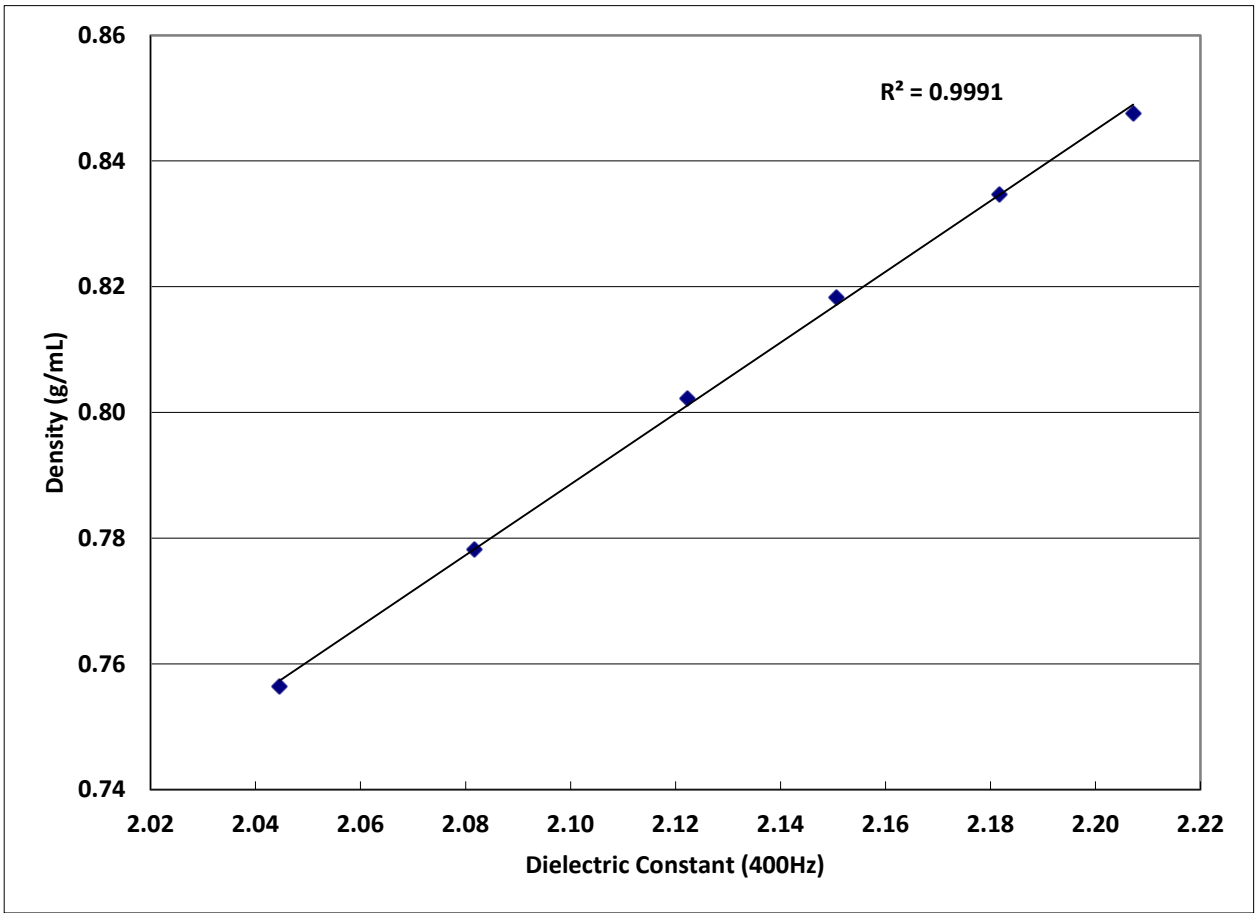

Figure F2-10. CL09-00342 (POSF4658 Jet A)

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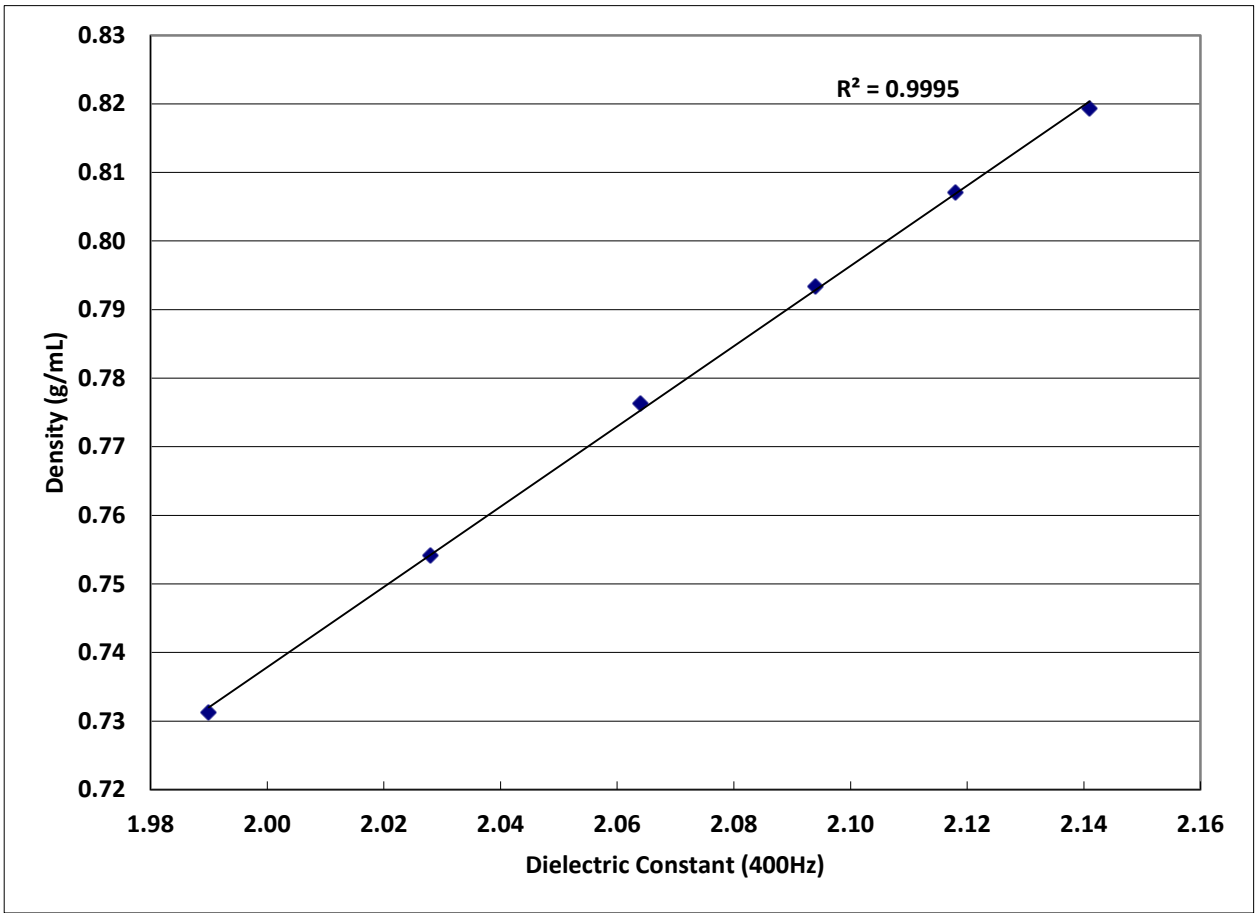

Figure F2-11. CL09-00343 (POSF5706 S-8 / Jet A)

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Appendix G

Miscellaneous Data

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Table G-1. Results for D6078 (SLBOCLE) Lubricity Tests

SwRI Sample Code			CL09-0751	CL09-0752
Test	Method	Units	JP-8 (POSF5803)	Sasol IPK + CI/LI (POSF5802)
Scuffing Load BOCLE	D6078			
Scuffing Load		grams	2750	1850

Table G-2. Results for D6079 (HFRR) Lubricity Tests

SwRI Sample Code			CL09-0751	CL09-0752	CL10-0796	CL10-0797
Test	Method	Units	JP-8 (POSF5803)	Sasol IPK + CI/LI (POSF5802)	56:44 POSF5698:POSF4765 (POSF6413)	56:44 POSF5698:POSF4765 w/JP-8 Additive (POSF6412)
HFRR @60°C	D6079					
Wear Scar Diameter		µm	710	650	630	660

Table G-3. Results for D6890 (IQT)

SwRI Sample Code			CL09-0753	CL09-0754	CL09-0755	CL09-0756	CL09-0873	CL10-1409
Test	Method	Units	Sasol IPK/JP8 Blend (POSF5618)	Sasol IPK/JP8 Blend (POSF5619)	RP-1 (POSF4572)	Sasol IPK/JP8 Blend (POSF5620)	JP-7 (POSF3327)	Fully Synthetic Aviation Biofuel (POSF6902)
Ignition Quality Test (IQT)	D6890							
Ignition Delay, ID		ms	5.269	5.223	4.497	5.278	3.783	4.525
Derived Cetane Number, DCN			38.7	39.0	44.4	38.6	52.5	44.19

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Table G-4. Results for Neat Tallow

SwRI Sample Code			CL10-0773
Test	Method	Units	Tallow (POSF6308)
Chemistry			
Elemental Analysis	D7111		
Al			265ppb
Ba			<100ppb
Ca			<100ppb
Cr			<100ppb
Cu			<100ppb
Fe			<100ppb
Li			<100ppb
Pb			<100ppb
Mg			<100ppb
Mn			<100ppb
Mo			<100ppb
Ni			<100ppb
K			<1ppm
P			<1ppm
Na			<1ppm
Si			<100ppb
Ag			<100ppb
Ti			<100ppb
V			<100ppb
Zn			<100ppb
Lubricity (BOCLE) vs. CI/LI Concentration	D5001		
0 mg/L		mm	1.00
5 mg/L		mm	0.85
10 mg/L		mm	0.58
15 mg/L		mm	0.57
20 mg/L		mm	0.51

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Table G-5. Comparative Lubricity Data

Sample ID	Fuel Description	BOCLE (D5001) mm	Scuffing-Load BOCLE (D6078) grams	HFRR (D6079) mm
CL10-0005	Clay-Treated Jet A	0.75	2700	0.72
CL10-0429	Jet A (Valero)	0.84	2650	0.72
CL09-0268	Sasol IPK	0.86	1950	0.84
CL10-0326	R-8	0.99	1950	0.73
CL10-0932	Tallow / JP-8	0.61	3900	0.71
CL10-0687	TS-1	0.58	2950	0.74
CL09-0992	JP-5	0.57	3950	0.71
CL10-1266	JP-8	0.53	3850	0.73
CL10-0773	Tallow	0.95	2450	0.71
CL10-0278	Camelina	0.93	2000	0.79
CL10-0327	Camelina / JP-8	0.62	3100	0.73
CL10-0428	R-8 / Jet A	0.86	2150	0.69

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Table G-6. Existent Gum Data

Sample	Description	Run 1 Average mg/100mL	Run 2 Average mg/100 mL
CL09-0636	R-8x	14	13
CL10-0278	Camelina	7	5
CL10-0326	R-8	2	2
CL10-0773	Tallow	2	1
CL10-1443	Boeing Jet Fuel JP-5 (HRJ-5)	<1 mg/100mL	1
CL10-1444	Boeing Bio Oil Derived Synthetic Paraffinic Kerosene - Jatropha Lot	1	2
CL10-1445	Boeing Bio Oil Derived Synthetic Paraffinic Kerosene - Camelina Lot	<1 mg/100mL	1
CL10-1446	Boeing Bio Oil Derived Synthetic Paraffinic Kerosene - Jatropha/Algae Lot	<1 mg/100mL	1
CL10-1447	Boeing Bio Oil Derived Synthetic Paraffinic Kerosene - Jatropha/Algae/Camelina Lot	1	2

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Appendix H

R-8/Jet A Data

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Table H-1. Results for R-8 / Jet A

SwRI Sample Code			CL10-0428
Test	**Method**	**Units**	**R-8 / Jet A 50/50 Blend**
Chemistry			
Hydrocarbon Types by Mass Spec	D2425		
Paraffins		mass%	70.70
Monocycloparaffins		mass%	19.00
Dicycloparaffins		mass%	0.00
Tricycloparaffins		mass%	0.00
TOTAL SATURATES		mass%	89.70
Alkylbenzenes		mass%	6.10
Indans/Tetralins		mass%	3.50
Indenes		mass%	0.00
Naphthalene		mass%	0.30
Naphthalene, Alkyl		mass%	0.30
Acenaphthenes		mass%	0.10
Acenaphthylenes		mass%	0.10
Tricyclic Aromatics		mass%	0.00
TOTAL AROMATICS		mass%	10.40
Aromatic Content	D1319		
Aromatics		vol%	7.8
Olefins		vol%	0.5
Saturates		vol%	91.7
Carbon/Hydrogen	D5291		
Carbon		%	84.94
Hydrogen		%	14.64
Hydrogen Content (NMR)	D3701	mass%	14.66
Carbonyls, Alcohols, Esters, Phenols	EPA 8260B/8270C	--	Appendix K
Nitrogen Content	D4629	mg/kg	2
Copper by AA	D3237M	ppb	6
Elemental Analysis	D7111		
Al		ppb	280
Ba		ppb	<100
Ca		ppb	<100
Cr		ppb	<100
Cu		ppb	<100
Fe		ppb	<100
Li		ppb	<100
Pb		ppb	<100
Mg		ppb	<100
Mn		ppb	<100
Mo		ppb	<100
Ni		ppb	<100
K		ppb	<1000
Na		ppb	<1000
Si		ppb	<100

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Table H-1. Results for R-8 / Jet A

SwRI Sample Code			CL10-0428
Test	**Method**	**Units**	**R-8 / Jet A 50/50 Blend**
Ag		ppb	<100
Ti		ppb	<100
V		ppb	<100
Zn		ppb	<100
Bulk Physical and Performance Properties			
Distillation	D86		
IBP		°C	147.2
5%		°C	171.8
10%		°C	173.9
15%		°C	175.8
20%		°C	178.8
30%		°C	184.4
40%		°C	190.2
50%		°C	195.8
60%		°C	204.3
70%		°C	214.6
80%		°C	228.8
90%		°C	249.4
95%		°C	262.8
FBP		°C	266.3
Residue		%	1.4
Loss		%	1.4
T50-T10		°C	21.9
T90-T10		°C	75.5
Simulated Distillation	D2887		
IBP		°C	117.30
5%		°C	146.40
10%		°C	158.70
15%		°C	166.10
20%		°C	170.30
25%		°C	174.60
30%		°C	178.20
35%		°C	182.70
40%		°C	188.30
45%		°C	193.60
50%		°C	197.00
55%		°C	202.30
60%		°C	208.90
65%		°C	215.80
70%		°C	221.00
75%		°C	229.80
80%		°C	238.60
85%		°C	251.80
90%		°C	264.70

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Table H-1. Results for R-8 / Jet A

SwRI Sample Code			CL10-0428
Test	**Method**	**Units**	**R-8 / Jet A 50/50 Blend**
95%		°C	277.00
FBP		°C	301.90
Vapor pressure (Absolute)	D6378		
0 °C		psi	0.14
10 °C		psi	0.20
20 °C		psi	0.24
30 °C		psi	0.29
40 °C		psi	0.36
50 °C		psi	0.46
60 °C		psi	0.61
70 °C		psi	0.82
80 °C		psi	1.11
90 °C		psi	1.51
100 °C		psi	2.02
110 °C		psi	2.74
120 °C		psi	3.67
JFTOT Breakpoint	D3241BP	°C	
Test Temperature		°C	>340
ASTM Code		rating	1
Maximum Pressure Drop		mm Hg	0.1
JFTOT deposit thickness	Ellipsometer		*not available*
Lubricity (BOCLE)	D5001	mm	0.92
Lubricity (BOCLE) vs. CI/LI Concentration	D5001		
0 mg/L		mm	0.94
5 mg/L		mm	0.72
10 mg/L		mm	0.66
15 mg/L		mm	0.60
20 mg/L		mm	0.59
Kinematic Viscosity	D445		
-40°C		cSt	9.47
-20°C		cSt	4.70
30°C		cSt	1.62
40°C		cSt	1.38
Specific Heat Capacity	E2716	kJ/kg.K	Table 3
Density	D4052		
5°C		kg/m^3	0.7883
15°C		kg/m^3	0.7810
40°C		kg/m^3	0.7617
60°C		kg/m^3	0.7467
80°C		kg/m^3	0.7316
Surface tension	D1331A		
-10°C		mN/m	28.9
25°C		mN/m	25.1
40°C		mN/m	23.4

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Table H-1. Results for R-8 / Jet A

SwRI Sample Code			CL10-0428
Test	**Method**	**Units**	**R-8 / Jet A 50/50 Blend**
Isothermal Tangent Bulk modulus @ 30°C	D6793		
0 psi		psig	196255
1000 psi		psig	207062
2000 psi		psig	218157
3000 psi		psig	229539
4000 psi		psig	241208
5000 psi		psig	253164
6000 psi		psig	265407
7000 psi		psig	277938
8000 psi		psig	290756
9000 psi		psig	303861
10000 psi		psig	317253
Isothermal Tangent Bulk modulus @ 60°C	D6793		
0 psi		psig	165292
1000 psi		psig	176435
2000 psi		psig	187937
3000 psi		psig	199801
4000 psi		psig	212025
5000 psi		psig	224609
6000 psi		psig	237554
7000 psi		psig	250859
8000 psi		psig	264524
9000 psi		psig	278551
10000 psi		psig	292937
Thermal Conductivity	SwRI		
0°C		W/m.K	0.1048
25°C		W/m.K	0.1037
50°C		W/m.K	0.1026
Water Content	D6304		
5°C		ppm	27
20°C		ppm	70
40°C		ppm	127
50°C		ppm	156
Flash Point - Tag Closed	D56	°C	45
Freeze Point (manual)	D2386	°C	-56.5
Freeze Point	D5972	°C	-60.0
Electrical Properties			
Dielectric Constant (400Hz)	SwRI		
-35.9°C		---	2.1311
-21.8°C		---	2.1131
1.1°C		---	2.0835
19.0°C		---	2.0610
52.4°C		---	2.0207
80.3°C		---	1.9857

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Table H-1. Results for R-8 / Jet A

SwRI Sample Code			CL10-0428
Test	**Method**	**Units**	**R-8 / Jet A 50/50 Blend**
Electrical Conductivity	D2624	pS/m	7
Electrical Conductivity vs. SDA Concentration	D2624		
0 mg/L		pS/m	0
1 mg/L		pS/m	502
2 mg/L		pS/m	975
3 mg/L		pS/m	1435
4 mg/L		pS/m	1905
Electrical Conductivity vs. Temperature	D2624		
-40		pS/m	0
-30		pS/m	4
-20		pS/m	4
-10		pS/m	6
0		pS/m	8
10		pS/m	1
20		pS/m	4
30		pS/m	8
40		pS/m	15
50		pS/m	44
60		pS/m	246
70		pS/m	389
80		pS/m	490
Ground Handling Properties and Safety			
MSEP	D3948	rating	98
Removal of Emulsified Water	SAE J1488	TWA WRE **	100.0 Table H-2
Storage Stability - Peroxides @65°C	D3703		
0 week		mg/kg	0.00
1 week		mg/kg	0.00
2 week		mg/kg	0.23
3 week		mg/kg	0.34
6 week		mg/kg	0.46
Storage Stability – Potential Gums	D5304		
16 hours		mg/100mL	0.2
Upper Explosion Limit (UEL), @100°C	E681	%	2.6
Lower Explosion Limit (LEL), @100°C	E681	%	0.3
Autoignition temperature	E659		
Hot Flame Autoignition Temperature		°C	241
Hot Flame Lag Time		seconds	60
Cool Flame Autoignition Temperature		°C	--
Cool Flame Lag Time		seconds	--
Barometric Pressure		mm Hg	739
Reaction Threshold Temperature		°C	226
Hot surface ignition	FTM 791-6053	°F	1275
Compatibility			
Fuel/Additive Compatibility (4x treat rate)	D4054B		

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Table H-1. Results for R-8 / Jet A

SwRI Sample Code			CL10-0428
Test	**Method**	**Units**	**R-8 / Jet A 50/50 Blend**
FSII		effect	*1st Set - Some separation*
		effect	*2nd Set – No separation*
SDA		effect	no separation
CI/LI		effect	no separation
MDA		effect	no separation
AO		effect	no separation
Additive Cocktail (MDA, AO, SDA, CI/LI, FSII)		effect	*1st Set - Some separation*
		effect	*2nd Set – No separation*
+100 (#1, P-39)		effect	no separation
+100 (#1, P-41)		effect	no separation
+100 (#1, P-44)		effect	no separation
+100 (#1, P-47)		effect	no separation
+100 (#1, P-50)		effect	no separation
+100 (Blend)		effect	no separation
Elastomer Compatibility (O-Ring Tests)	SwRI		Figure H-1, Figure H-3, Figure H-2
Miscellaneous			
Copper Strip Corrosion (100°C for 2 hours)	D130	rating	1A
Smoke Point	D1322	mm	25.0
Naphthalene Content	D1840	vol%	0.07
Sulfur - Mercaptan	D3227	mass%	<0.0003
Acid Number	D3242	mg KOH/g	0.003
Existent Gums	D381	mg/100mL	1.20
Heat of Combustion	D4809		
BTUHeat_Gross		BTU/lb	20071.3
BTUHeat_Net		BTU/lb	18733.9
MJHeat_Gross		MJ/kg	46.68
MJHeat_Net		MJ/kg	43.57
Sulfur Content - (Antek)	D5453	ppm	0.4
Scuffing Load BOCLE	D6078	grams	1200
HFRR @ 60°C	D6079	µm	740
Ignition Quality Test (IQT)	D6890		
Ignition Delay, ID		ms	3.93
Derived Cetane Number, DCN			50.51
Minimum Ignition Energy	E582	mJ	0.25
Sulfur Content	D2622	ppm	<10

**TWA WRE = Time-Weighted Average Water Removal Efficiency

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Table H-2. SAE J1488 – R-8/Jet A

Test Description	SAE J1488	**Test No**	3
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC#3
Test Fluid	CL10-0428	**Test Date**	8/23/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	26
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	96
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100555

Average Upstream Water Content, ppm	2589
Time Weighted Average Water Removal Efficiency (%)	100.0
Total Water from Test Housing, mL	2092
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	25.1

MSEP

Before	96

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	96	55	0	9.2	0
2	10	1790	66	0	10.1	28
3	30	2230	57	0	10.1	207
4	50	2440	59	0	10.4	280
5	70	2510	64	0	10.6	298
6	90	2430	64	0	10.4	305
7	110	3170	85	0	10.5	409
8	130	3190	56	0	10.4	247
9	150	2950	54	0	10.6	318

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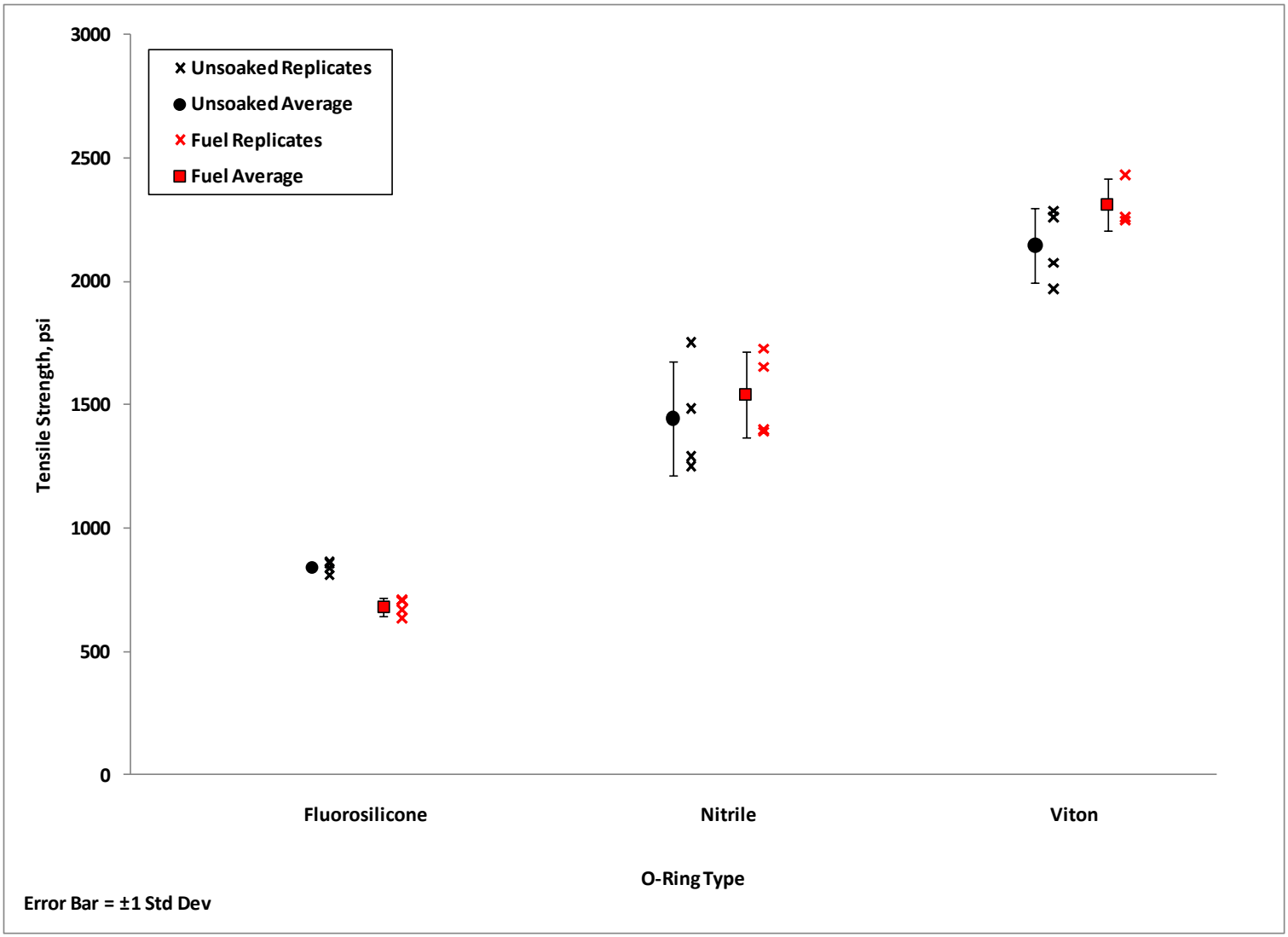

Figure H-1. O-ring Tensile Strength – R-8/Jet A

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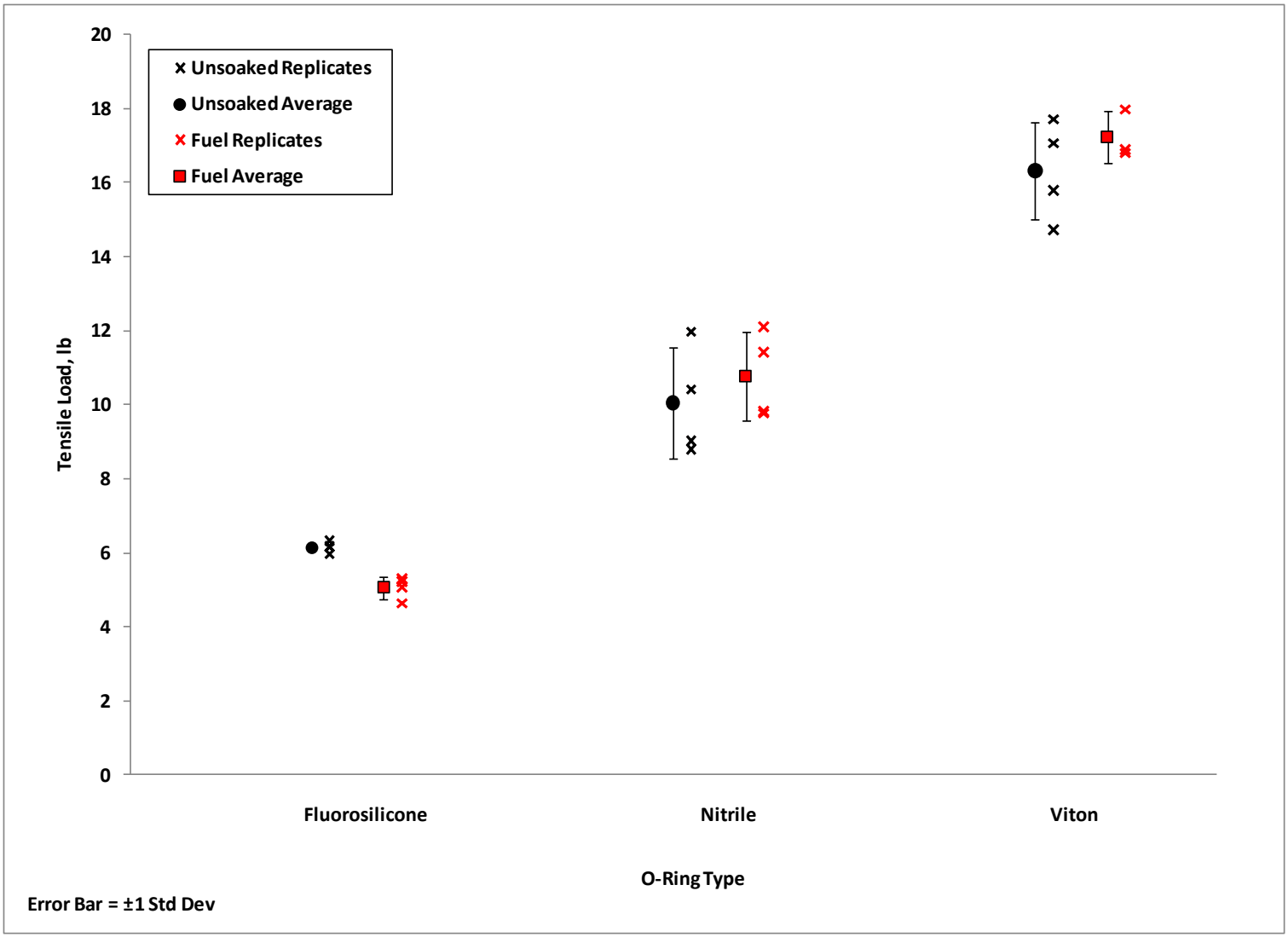

Figure H-2. O-ring Tensile Load – R-8/Jet A

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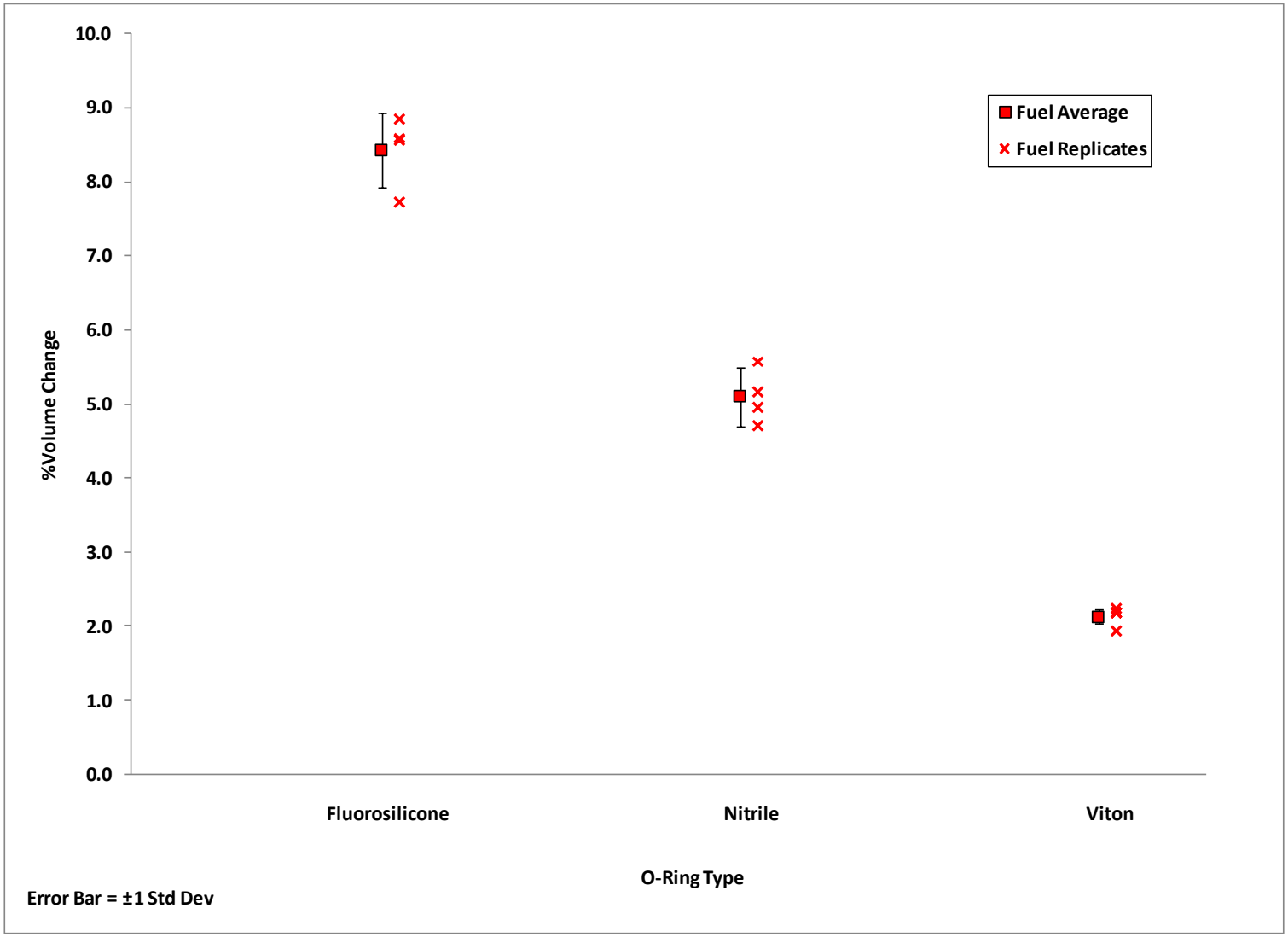

Figure H-3. O-ring Volume Change – R-8/Jet A

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Appendix I

Camelina and Camelina / JP-8 Data

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Table I-1. Results for Camelina and Camelina / JP-8

SwRI Sample Code			CL10-0278	CL10-0327
Test	Method	Units	Camelina, HJR8 neat (POSF6152)	Camelina / JP-8 50/50 Blend (POSF6184)
Chemistry				
Hydrocarbon Types by Mass Spec	D2425			
Paraffins		mass%	92.4	67.6
Monocycloparaffins		mass%	7.4	14.3
Dicycloparaffins		mass%	0.0	4.6
Tricycloparaffins		mass%	0.0	1.1
TOTAL SATURATES		mass%	99.8	87.6
Alkylbenzenes		mass%	0.2	5.4
Indans/Tetralins		mass%	0.0	4.6
Indenes		mass%	0.0	0.3
Naphthalene		mass%	0.0	0.4
Naphthalene, Alkyl		mass%	0.0	1.4
Acenaphthenes		mass%	0.0	0.3
Acenaphthylenes		mass%	0.0	0.1
Tricyclic Aromatics		mass%	0.0	0.0
TOTAL AROMATICS		mass%	0.2	12.5
Aromatic Content	D1319			
Aromatics		vol%	0.0	9.0
Olefins		vol%	0.5	0.9
Saturates		vol%	99.5	90.1
Carbon/Hydrogen	D5291			
Carbon		mass%	83.98	84.70
Hydrogen		mass%	15.26	14.56
Hydrogen Content (NMR)	D3701	mass%	15.38	14.58
Carbonyls, Alcohols, Esters, Phenols	EPA 8260B/8270C	--	Appendix K	Appendix K
Nitrogen Content	D4629	mg/kg	2	2
Copper by AA	D3237M	ppb	<5	<5
Elemental Analysis	D7111			
Al		--	157ppb	<100ppb
Ba		--	<100ppb	<100ppb
Ca		--	102ppb	397ppb
Cr		--	<100ppb	<100ppb
Cu		--	<100ppb	<100ppb
Fe		--	<100ppb	<100ppb
Li		--	<100ppb	<100ppb
Pb		--	<100ppb	<100ppb
Mg		--	<100ppb	<100ppb
Mn		--	<100ppb	<100ppb
Mo		--	<100ppb	<100ppb
Ni		--	<100ppb	<100ppb
K		--	<1ppm	<1ppm
Na		--	<1ppm	<1ppm

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Table I-1. Results for Camelina and Camelina / JP-8

SwRI Sample Code			CL10-0278	CL10-0327
Test	**Method**	**Units**	**Camelina, HJR8 neat (POSF6152)**	**Camelina / JP-8 50/50 Blend (POSF6184)**
Si		--	2.9ppm	<100ppb
Ag		--	<100ppb	<100ppb
Ti		--	<100ppb	<100ppb
V		--	<100ppb	<100ppb
Zn		--	<100ppb	161ppb
Bulk Physical and Performance Properties				
Distillation	D86			
IBP		°C	150.9	154.3
5%		°C	161.0	166.9
10%		°C	161.2	168.1
15%		°C	163.4	171.0
20%		°C	165.5	174.6
30%		°C	169.7	181.2
40%		°C	175.5	188.6
50%		°C	182.6	197.2
60%		°C	192.2	206.3
70%		°C	204.1	216.7
80%		°C	220.5	228.2
90%		°C	240.0	242.9
95%		°C	252.3	254.7
FBP		°C	256.8	262.1
Residue		%	1.4	1.2
Loss		%	1.4	1.4
T50-T10		°C	21.4	29.1
T90-T10		°C	78.8	74.8
Simulated Distillation	D2887			
IBP		°C	119.0	117.6
5%		°C	137.5	142.1
10%		°C	143.1	146.3
15%		°C	145.0	157.6
20%		°C	152.3	165.5
25%		°C	158.5	168.7
30%		°C	164.6	175.5
35%		°C	166.7	181.6
40%		°C	169.3	188.2
45%		°C	177.5	194.7
50%		°C	181.9	199.7
55%		°C	187.9	207.4
60%		°C	195.3	212.8
65%		°C	202.5	218.6
70%		°C	210.4	226.2
75%		°C	220.0	232.8
80%		°C	229.0	239.5
85%		°C	239.7	248.7

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Table I-1. Results for Camelina and Camelina / JP-8

SwRI Sample Code			CL10-0278	CL10-0327
Test	**Method**	**Units**	**Camelina, HJR8 neat (POSF6152)**	**Camelina / JP-8 50/50 Blend (POSF6184)**
90%		°C	253.8	258.0
95%		°C	265.9	269.8
FBP		°C	286.8	293.7
Vapor pressure (Absolute)	D6378			
0 °C		psi	0.13	0.12
10 °C		psi	0.19	0.17
20 °C		psi	0.24	0.21
30 °C		psi	0.29	0.26
40 °C		psi	0.38	0.33
50 °C		psi	0.50	0.42
60 °C		psi	0.69	0.56
70 °C		psi	0.96	0.76
80 °C		psi	1.31	1.03
90 °C		psi	1.79	1.41
100 °C		psi	2.42	1.90
110 °C		psi	3.26	2.57
120 °C		psi	4.35	3.44
JFTOT Breakpoint	D3241BP	°C		
Test Temperature		°C	335	305
ASTM Code		rating	2	<3
Maximum Pressure Drop		mm Hg	0.1	1.0
JFTOT deposit thickness	Ellipsometer	nm	*not available*	*not available*
Lubricity (BOCLE)	D5001	mm	0.92	0.69
Lubricity (BOCLE) vs. CI/LI Concentration	D5001			
0 mg/L		mm	0.94	0.68
5 mg/L		mm	0.73	0.62
10 mg/L		mm	0.64	0.58
15 mg/L		mm	0.60	0.57
20 mg/L		mm	0.57	0.56
Kinematic Viscosity	D445			
-40°C		cSt	5.96	7.02
-20°C		cSt	3.66	4.14
30°C		cSt	1.35	1.44
40°C		cSt	1.10	1.21
Specific Heat Capacity	E2716	kJ/kg.K	Table 3	Table 3
Density	D4052			
5°C		g/cm^3	0.7581	0.7849
15°C		g/cm^3	0.7504	0.7773
40°C		g/cm^3	0.7316	0.7586
60°C		g/cm^3	0.7163	0.7435
80°C		g/cm^3	0.7012	0.7284
Surface tension	D1331A			
-10°C		mN/m	--	25.4

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Table I-1. Results for Camelina and Camelina / JP-8

SwRI Sample Code			CL10-0278	CL10-0327
Test	**Method**	**Units**	**Camelina, HJR8 neat (POSF6152)**	**Camelina / JP-8 50/50 Blend (POSF6184)**
23°C		mN/m	--	24.0
40°C		mN/m	--	23.4
Isothermal Tangent Bulk modulus @ 30°C	D6793			
0 psi		psig	--	193202
1000 psi		psig	--	204005
2000 psi		psig	--	215100
3000 psi		psig	--	226486
4000 psi		psig	--	238164
5000 psi		psig	--	250133
6000 psi		psig	--	262393
7000 psi		psig	--	274945
8000 psi		psig	--	287788
9000 psi		psig	--	300923
10000 psi		psig	--	314348
Isothermal Tangent Bulk modulus @ 60°C	D6793			
0 psi		psig	--	161921
1000 psi		psig	--	173560
2000 psi		psig	--	185600
3000 psi		psig	--	198041
4000 psi		psig	--	210883
5000 psi		psig	--	224126
6000 psi		psig	--	237770
7000 psi		psig	--	251815
8000 psi		psig	--	266261
9000 psi		psig	--	281107
10000 psi		psig	--	296355
Thermal Conductivity	SwRI			
0°C		W/m.K	--	0.1071
25°C		W/m.K	--	0.1020
50°C		W/m.K	--	0.0968
Water Content	D6304	ppm	24	--
Water Content vs Temperature	D6304			
4°C		ppm	--	50
24°C		ppm	--	115
37°C		ppm	--	149
46°C		ppm	--	180
Flash Point - Tag Closed	D56	°C	38	46
Freeze Point (manual)	D2386	°C	-65.5	-51.0
Freeze Point	D5972	°C	-69.4	-55.9
Electrical Properties				
Dielectric Constant (400kHz)	SwRI			
-36.1°C		---	--	2.1459
-17.7°C		---	--	2.1200
0.0°C		---	--	2.0952

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Table I-1. Results for Camelina and Camelina / JP-8

SwRI Sample Code			CL10-0278	CL10-0327
Test	**Method**	**Units**	**Camelina, HJR8 neat (POSF6152)**	**Camelina / JP-8 50/50 Blend (POSF6184)**
24.8°C		---	--	2.0628
52.2°C		---	--	2.0290
83.9°C		---	--	1.9869
Electrical Conductivity	D2624	pS/m	--	290
Electrical Conductivity vs. SDA Concentration	D2624			
0 mg/L		pS/m	--	13
1 mg/L		pS/m	--	627
2 mg/L		pS/m	--	1248
3 mg/L		pS/m	--	1659
4 mg/L		pS/m	--	1971
Electrical Conductivity vs. Temperature	D2624			
-40.7		pS/m	--	17
-30.5		pS/m	--	23
-20		pS/m	--	33
-10		pS/m	--	44
0.1		pS/m	--	70
10.1		pS/m	--	121
20.3		pS/m	--	234
30		pS/m	--	303
40.1		pS/m	--	338
50		pS/m	--	361
59.8		pS/m	--	410
Ground Handling Properties and Safety				
MSEP	D3948	rating	--	73
Removal of Emulsified Water	SAE J1488	TWA WRE **	--	99.1 Table I-2
Storage Stability - Peroxides @65°C	D3703			
0 week		mg/kg	--	0.13
1 week		mg/kg	--	0.11
2 week		mg/kg	--	0.57
3 week		mg/kg	--	0.23
6 week		mg/kg	--	0.00
Storage Stability – Potential Gums	D5304			
16 hours		mg/100mL	--	<0.1
Upper Explosion Limit (UEL), @100°C	E681	%	--	4.3
Lower Explosion Limit (LEL), @100°C	E681	%	--	0.5
Autoignition temperature	E659			
Hot Flame Autoignition Temperature		°C	--	225
Hot Flame Lag Time		seconds	--	163.0
Cool Flame Autoignition Temperature		°C	--	--
Cool Flame Lag Time		seconds	--	--
Barometric Pressure		mm Hg	--	736.5
Reaction Threshold Temperature		°C	--	213
Hot Surface Ignition Temperature	FTM 791-6053	°F	--	1250

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Table I-1. Results for Camelina and Camelina / JP-8

SwRI Sample Code			CL10-0278	CL10-0327
Test	**Method**	**Units**	**Camelina, HJR8 neat (POSF6152)**	**Camelina / JP-8 50/50 Blend (POSF6184)**
Compatibility				
Fuel/Additive Compatibility (4x treat rate)	D4054B			
FSII		effect	--	no separation
SDA		effect	--	no separation
CI/LI		effect	--	no separation
MDA		effect	--	no separation
AO		effect	--	no separation
+100 (#1, P-39)		effect	--	no separation
+100 (#2, P-41)		effect	--	no separation
+100 (#3, P-44)		effect	--	no separation
+100 (#4, P-47)		effect	--	no separation
+100 (#5, P-50)		effect	--	no separation
+100 (Blend)		effect	--	no separation
Elastomer Compatibility (O-Ring Tests)	SwRI		--	Figure I-1, Figure I-2, Figure I-3
Miscellaneous				
Copper Strip Corrosion (100°C for 2 hours)	D130	rating	--	1A
Smoke Point	D1322	mm	24.0	22.0
Naphthalene Content	D1840	vol%	--	0.51
Sulfur - Mercaptan	D3227	mass%	--	<0.0003
Acid Number	D3242	mg KOH/g	0.003	0.005
Existent Gums	D381	mg/100mL	--	<0.5
Heat of Combustion	D4809			
BTUHeat_Gross		BTU/lb	--	20073.5
BTUHeat_Net		BTU/lb	--	18745.2
MJHeat_Gross		MJ/kg	--	46.68
MJHeat_Net		MJ/kg	--	43.59
Sulfur Content - (Antek)	D5453	ppm	0.9	184.7
Scuffing Load BOCLE	D6078	grams	--	1700
HFRR @ 60°C	D6079	µm	--	680
Ignition Quality Test (IQT)	D6890			
Ignition Delay, ID		ms	3.686	4.036
Derived Cetane Number, DCN			53.94	49.22
Minimum Ignition Energy	E582	mJ	--	0.68
Sulfur Content	D2622	ppm	--	206

**TWA WRE = Time-Weighted Average Water Removal Efficiency

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Table I-2. SAE J1488 – Camelina/JP-8

Fuel/Water Separation Test Stand
SAE J1488 Data Sheet

Client: UTC
Project Number: 1.08.07.13.15498.01.101
Test Engineer: Kavitha Moorthy
Test Fluid: CL10-0327
Water Injection Rate (mL/min): 19
Water Saturation Limit (ppm):

Test Number: 1
Filter ID: FL10-0017(6/6 & 1/6), FL10-0016(23/24)
Test Date: 4/30/10
Test Fluid Flow Rate (LPM): 7.6
Test Temperature (°C): 26.6
Pressure

Fuel/Water Interfacial Tension (mN/m)

	Before Additive
BOT	34.9
EOT	31.5

MSEP	Before Additive
BOT	74
EOT	53

Sample Identification	Time (minutes)	Downstream Water Content (ppm)	Free Water Content (ppm)	Pressure Drop (kPa)	Water Drained (mL)
1	0	47		5.6	0
2	10	28	0	5.6	1
3	30	36	0	6.8	3
4	50	66	17	7.8	73
5	70	84	36	8.5	0
6	90	59	11	8.8	400
7	110	122	74	8.9	326
8	130	83	35	9	273
9	150	42	0	9	223

Average Water Content (ppm):	2296
Time Weighted Average Water Removal Efficiency(%):	99.1
Water from Test Housing (mL):	1300
Water from Cleanup Filters (mL):	0

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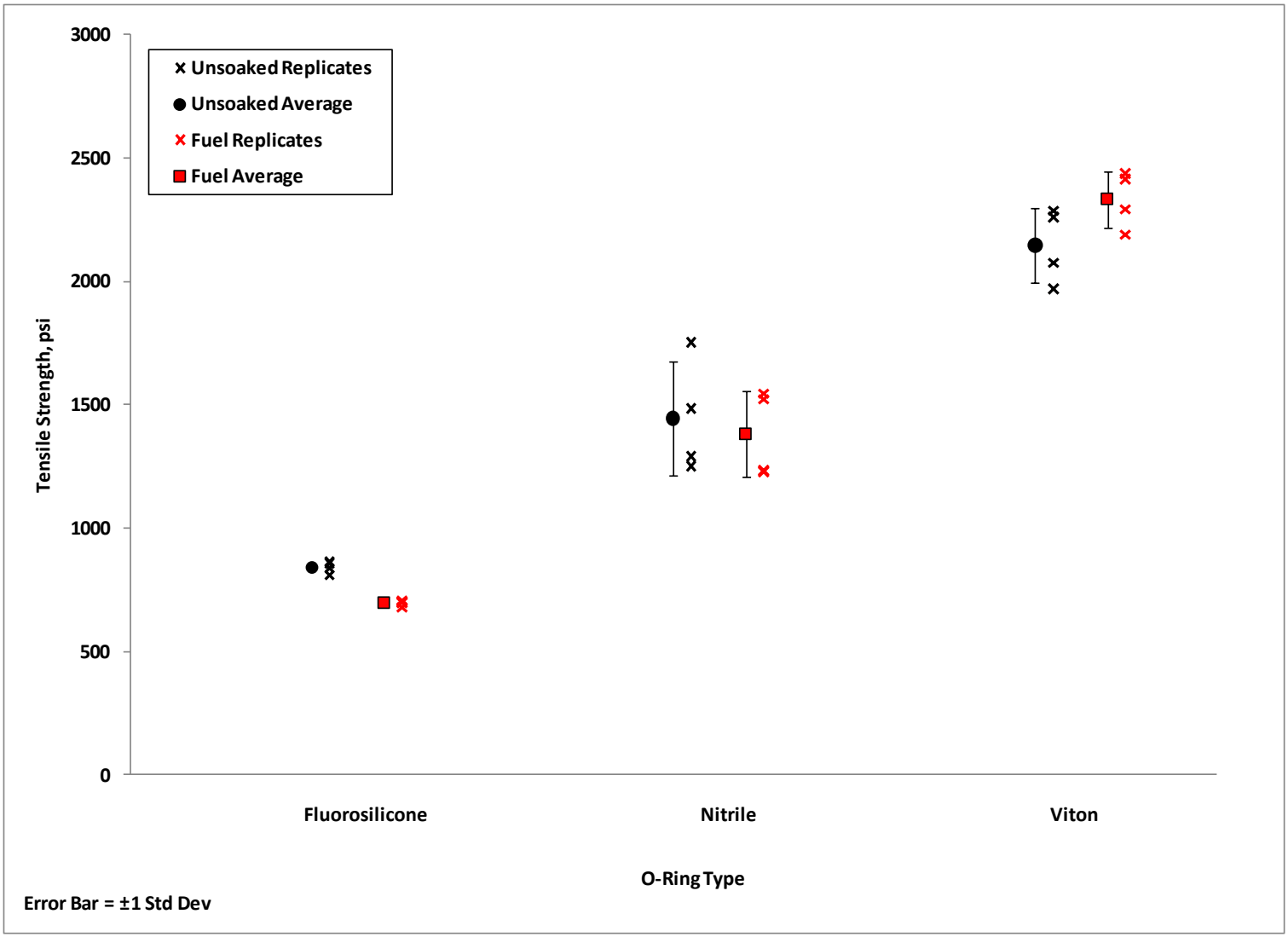

Figure I-1. O-ring Tensile Strength – Camelina/JP-8

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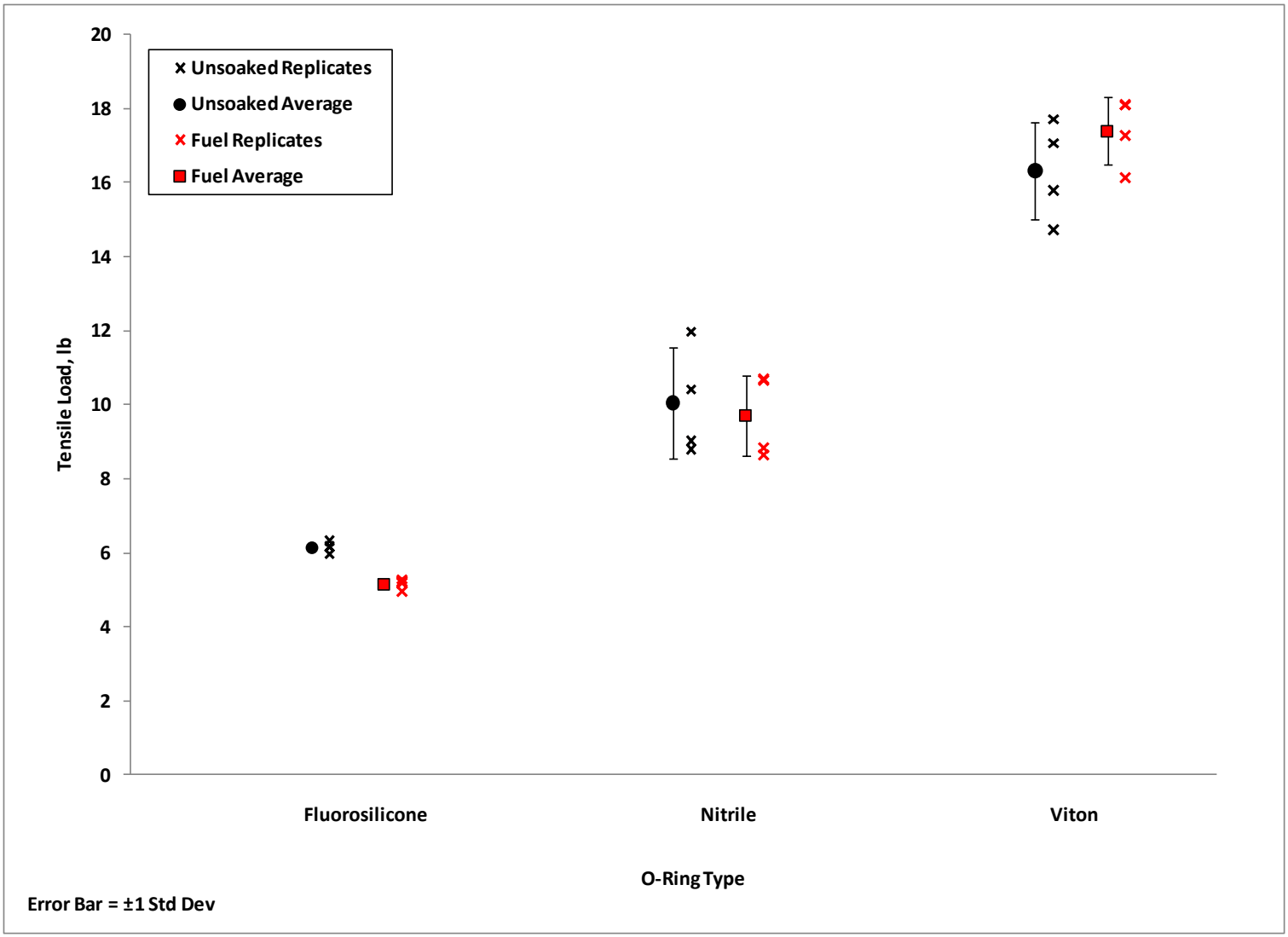

Figure I-2. O-ring Tensile Load – Camelina/JP-8

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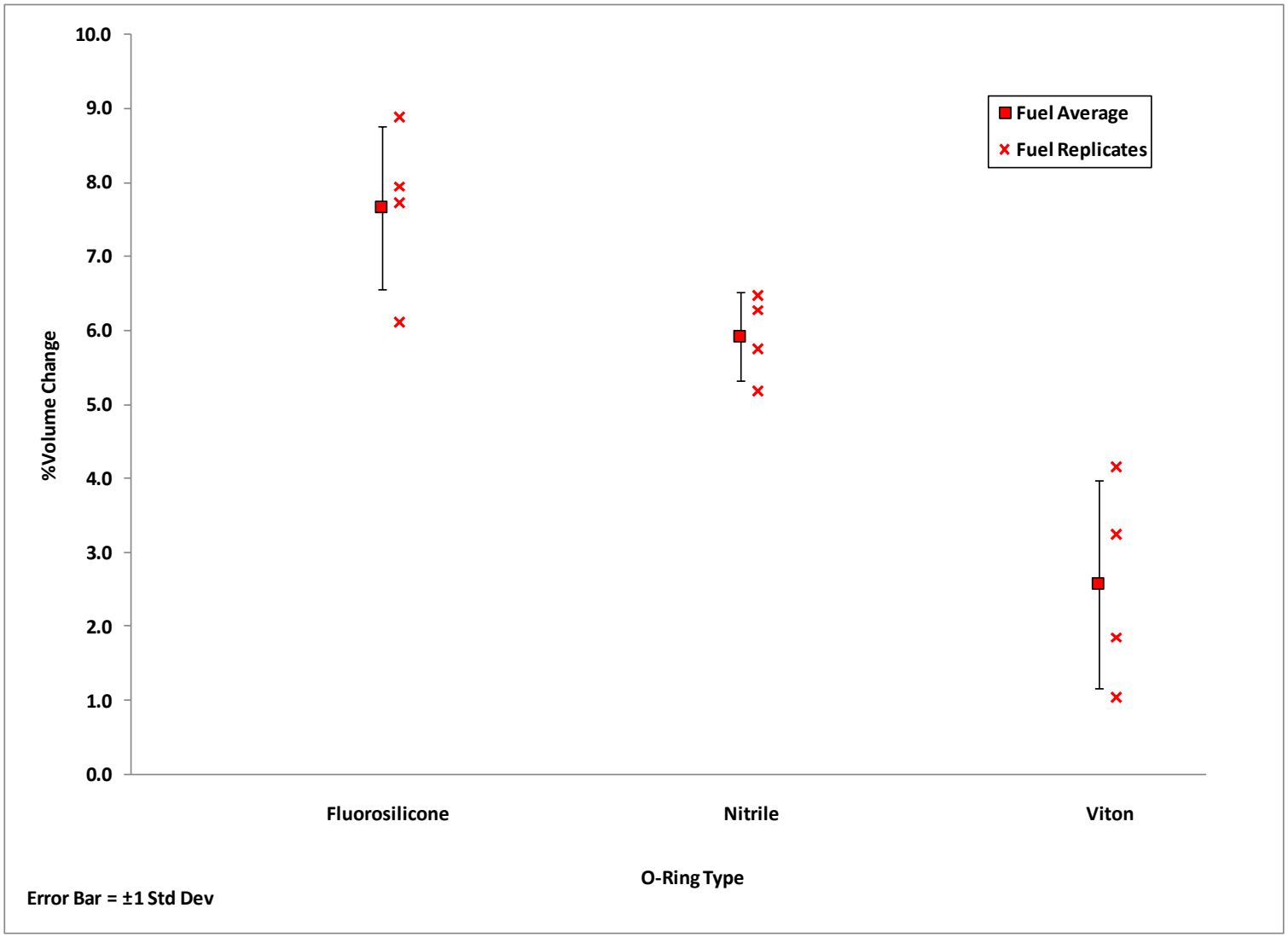

Figure I-3. O-ring Volume Change – Camelina/JP-8

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Appendix J

Tallow / JP-8 Data

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Table J-1. Results for Tallow / JP-8

SwRI Sample Code			CL10-0932
Test	**Method**	**Units**	**Tallow / JP-8 50/50 Blend (POSF6406)**
Chemistry			
Hydrocarbon Types by Mass Spec	D2425		
Paraffins		mass%	74.5
Monocycloparaffins		mass%	11.0
Dicycloparaffins		mass%	3.7
Tricycloparaffins		mass%	0.8
TOTAL SATURATES		mass%	90.0
Alkylbenzenes		mass%	5.5
Indans/Tetralins		mass%	3.3
Indenes		mass%	0.2
Naphthalene		mass%	0.3
Naphthalene, Alklyl+A130+A172		mass%	0.5
Acenaphthenes		mass%	0.1
Acenaphthylenes		mass%	0.1
Tricyclic Aromatics		mass%	0.0
TOTAL AROMATICS		mass%	10.0
Aromatic Content	D1319		
Aromatics		vol%	9.40
Olefins		vol%	1.30
Saturates		vol%	89.30
Carbon/Hydrogen	D5291		
Carbon		%	85.29
Hydrogen		%	14.57
Hydrogen Content (NMR)	D3701	mass%	14.61
Carbonyls, Alcohols, Esters, Phenols	EPA 8260B/8270C	--	Appendix L
Nitrogen Content	D4629	mg/kg	3
Copper by AA	D3237M	ppb	<5
Elemental Analysis	D7111		
Al		ppm	162ppb
Ba		ppm	<100ppb
Ca		ppm	159ppb
Cr		ppm	<100ppb
Cu		ppm	<100ppb
Fe		ppm	<100ppb
Li		ppm	<100ppb
Pb		ppm	<100ppb
Mg		ppm	<100ppb
Mn		ppm	<100ppb
Mo		ppm	<100ppb
Ni		ppm	<100ppb
K		ppm	<1ppm
Na		ppm	<1ppm
Si		ppm	523ppb
Ag		ppm	<100ppb

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Table J-1. Results for Tallow / JP-8

SwRI Sample Code			CL10-0932
Test	**Method**	**Units**	**Tallow / JP-8 50/50 Blend (POSF6406)**
Ti		ppm	<100ppb
V		ppm	<100ppb
Zn		ppm	<100ppb
Bulk Physical and Performance Properties			
Distillation	D86		
IBP		°C	164.7
5%		°C	177.2
10%		°C	179.8
15%		°C	183.9
20%		°C	187.3
30%		°C	195.1
40%		°C	202.2
50%		°C	209.5
60%		°C	217.6
70%		°C	225.7
80%		°C	234.2
90%		°C	244.1
95%		°C	251.2
FBP		°C	258.0
Residue		%	1.3
Loss		%	0.9
T50-T10		°C	29.7
T90-T10		°C	64.3
Simulated Distillation	D2887		
IBP		°C	119.0
5%		°C	145.5
10%		°C	160.0
15%		°C	167.5
20%		°C	175.1
25%		°C	182.5
30%		°C	189.0
35%		°C	195.9
40%		°C	200.6
45%		°C	207.5
50%		°C	211.9
55%		°C	217.4
60%		°C	223.4
65%		°C	229.6
70%		°C	236.1
75%		°C	243.1
80%		°C	249.2
85%		°C	254.7
90%		°C	259.5
95%		°C	266.0

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Table J-1. Results for Tallow / JP-8

SwRI Sample Code			CL10-0932
Test	**Method**	**Units**	**Tallow / JP-8 50/50 Blend (POSF6406)**
FBP		°C	299.0
Vapor pressure (Absolute)	D6378		
0 °C		psi	0.13
10 °C		psi	0.20
20 °C		psi	0.24
30 °C		psi	0.29
40 °C		psi	0.36
50 °C		psi	0.45
60 °C		psi	0.58
70 °C		psi	0.77
80 °C		psi	1.02
90 °C		psi	1.35
100 °C		psi	1.79
110 °C		psi	2.36
120 °C		psi	3.13
JFTOT Breakpoint	D3241BP	°C	
Test Temperature		°C	325
ASTM Code		rating	2
Maximum Pressure Drop		mm Hg	0.10
JFTOT deposit thickness	Ellipsometer		*not available*
Lubricity (BOCLE)	D5001	mm	0.550
Lubricity (BOCLE) vs. CI/LI Concentration	D5001		
0 mg/L		mm	0.815
5 mg/L		mm	0.710
10 mg/L		mm	0.635
15 mg/L		mm	0.610
20 mg/L		mm	0.575
Kinematic Viscosity	D445		
-39.95°C		cSt	10.06
-19.95°C		cSt	4.73
25°C		cSt	1.72
40°C		cSt	1.35
Specific Heat Capacity	E2716	kJ/kg.K	Table 3
Density	D4052		
5°C		g/cm^3	0.7880
15°C		g/cm^3	0.7806
25°C		g/cm^3	0.7733
40°C		g/cm^3	0.7625
60°C		g/cm^3	0.7474
80°C		g/cm^3	0.7325
Surface tension	D1331A		
-12.2°C		mN/m	27.2
22.5°C		mN/m	24.9

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Table J-1. Results for Tallow / JP-8

SwRI Sample Code			CL10-0932
Test	**Method**	**Units**	**Tallow / JP-8 50/50 Blend (POSF6406)**
41.3°C		mN/m	23.4
Isothermal Tangent Bulk modulus @ 30°C	D6793		
0 psi		psig	194589
1000 psi		psig	205653
2000 psi		psig	217020
3000 psi		psig	228691
4000 psi		psig	240665
5000 psi		psig	252943
6000 psi		psig	265524
7000 psi		psig	278408
8000 psi		psig	291596
9000 psi		psig	305087
10000 psi		psig	318881
Isothermal Tangent Bulk modulus @ 60°C	D6793		
0 psi		psig	166688
1000 psi		psig	177595
2000 psi		psig	188846
3000 psi		psig	200439
4000 psi		psig	212375
5000 psi		psig	224653
6000 psi		psig	237275
7000 psi		psig	250239
8000 psi		psig	263546
9000 psi		psig	277195
10000 psi		psig	291188
Thermal Conductivity	SwRI		
0°C		W/m.K	0.1111
25°C		W/m.K	0.1100
50°C		W/m.K	0.1090
Water Content	D6304	ppm	45
Water Content	D6304		
5°C		ppm	34
20°C		ppm	56
40°C		ppm	142
50°C		ppm	423
Flash Point - Tag Closed	D56	°C	51
Freeze Point (manual)	D2386	°C	-48.0
Freeze Point	D5972	°C	-53.9
Electrical Properties			
Dielectric Constant (10kHz)	SwRI		
-33.0°C		---	2.1502
-17.1°C		---	2.1269
0.8°C		---	2.1051
19.9°C		---	2.0771

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Table J-1. Results for Tallow / JP-8

SwRI Sample Code			CL10-0932
Test	**Method**	**Units**	**Tallow / JP-8 50/50 Blend (POSF6406)**
39.3°C		---	2.0524
79.9°C		---	2.0011
Electrical Conductivity	D2624	pS/m	357
Electrical Conductivity vs. SDA Concentration	D2624		
0 mg/L		pS/m	3
1 mg/L		pS/m	233
2 mg/L		pS/m	429
3 mg/L		pS/m	622
4 mg/L		pS/m	811
Electrical Conductivity vs. Temperature	D2624		
-40		pS/m	30
-30		pS/m	68
-20		pS/m	102
-10		pS/m	121
0		pS/m	154
10		pS/m	187
20		pS/m	306
30		pS/m	375
40		pS/m	476
50		pS/m	718
60		pS/m	1061
70		pS/m	1571
80		pS/m	>2000
Ground Handling Properties and Safety			
MSEP	D3948	rating	85
Removal of Emulsified Water	SAE J1488	TWA WRE **	99.9 Table J-2
Storage Stability - Peroxides @65°C	D3703		
0 week		mg/kg	0.000
1 week		mg/kg	0.456
2 week		mg/kg	1.256
3 week		mg/kg	0.571
6 week		mg/kg	0.570
Storage Stability – Potential Gums	D5304		
16 hours		mg/100mL	0.00
Upper Explosion Limit (UEL), @100°C	E681	%	4.3
Lower Explosion Limit (LEL), @100°C	E681	%	0.5
Autoignition temperature	E659		
Hot Flame Autoignition Temperature		°C	223
Hot Flame Lag Time		seconds	186
Cool Flame Autoignition Temperature		°C	--
Cool Flame Lag Time		seconds	--
Barometric Pressure		mm Hg	735
Reaction Threshold Temperature		°C	212

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Table J-1. Results for Tallow / JP-8

SwRI Sample Code			CL10-0932
Test	**Method**	**Units**	**Tallow / JP-8 50/50 Blend (POSF6406)**
Hot surface ignition	FTM 791-6053	°F	1200
Compatibility			
Fuel/Additive Compatibility (4x treat rate)	D4054B		
FSII		effect	*1st Run: Some Separation*
			2nd Run: No Separation
SDA		effect	no separation
CI/LI		effect	no separation
MDA		effect	no separation
AO		effect	no separation
Additive Cocktail (MDA, AO, SDA, CI/LI, FSII)		effect	*Some Separation*
+100 (#1, P-39)		effect	no separation
+100 (#2, P-41)		effect	no separation
+100 (#3, P-44)		effect	no separation
+100 (#4, P-47)		effect	no separation
+100 (#5, P-50)		effect	no separation
+100 (Blend)		effect	no separation
Elastomer Compatibility (O-Ring Tests)	SwRI		Figure J-1, Figure J-2, Figure J-3
Miscellaneous			
Copper Strip Corrosion (100°C for 3 hours)	D130	rating	1A
Smoke Point	D1322	mm	24.2
Naphthalene Content	D1840	vol%	0.44
Sulfur - Mercaptan	D3227	mass%	<0.0003
Acid Number	D3242	mg KOH/g	0.003
Existent Gums	D381	mg/100mL	<0.5
Heat of Combustion	D4809		
BTUHeat_Gross		BTU/lb	20111.40
BTUHeat_Net		BTU/lb	18782.20
MJHeat_Gross		MJ/kg	46.77
MJHeat_Net		MJ/kg	43.68
Sulfur Content - (Antek)	D5453	ppm	181
Scuffing Load BOCLE	D6078	grams	1650
HFRR @ 60°C	D6079	µm	710
Ignition Quality Test (IQT)	D6890		
Ignition Delay, ID		ms	3.987
Derived Cetane Number, DCN			49.82
Minimum Ignition Energy	E582	mJ	0.63
Sulfur Content - (XRY)	D2622	ppm	198

**TWA WRE = Time-Weighted Average Water Removal Efficiency

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Table J-2. SAE J1488 – Tallow/JP-8

Test Description	SAE J1488	**Test No**	2
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC#3
Test Fluid	CL10-0932	**Test Date**	8/20/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	25
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	110
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100555

Average Upstream Water Content, ppm	2426
Time Weighted Average Water Removal	99.9
Total Water from Test Housing, mL	1910
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	26.4

MSEP

Before	43

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	110	86	0	8	0
2	10	2680	68	0	8.7	85
3	30	1840	121	11	9.2	189
4	50	2390	63	0	9.4	237
5	70	2000	66	0	9.7	259
6	90	2610	102	0	9.8	241
7	110	2970	45	0	9.9	318
8	130	2440	52	0	10	306
9	150	2480	60	0	10.2	275

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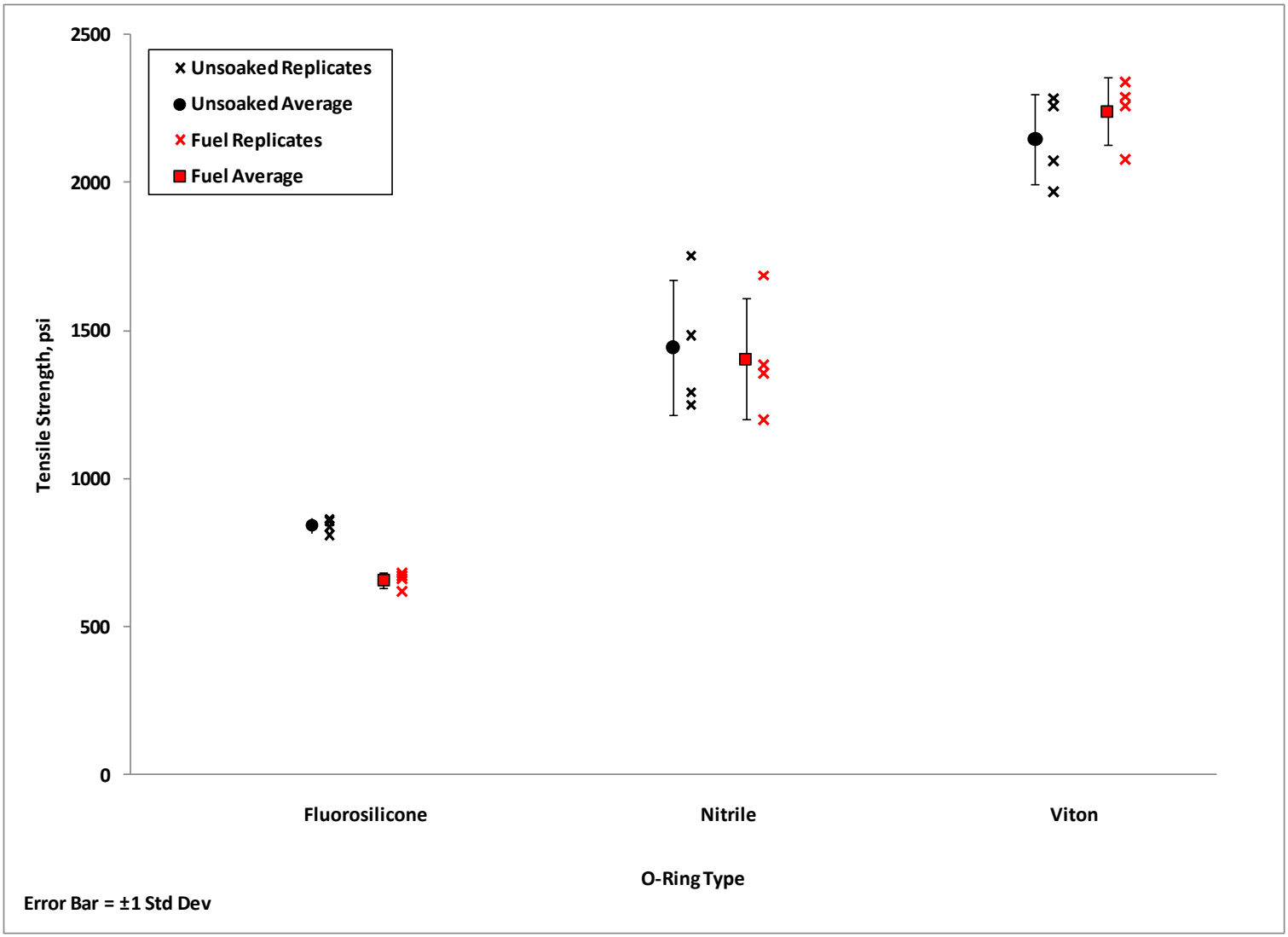

Figure J-1. O-ring Tensile Strength – Tallow/JP-8

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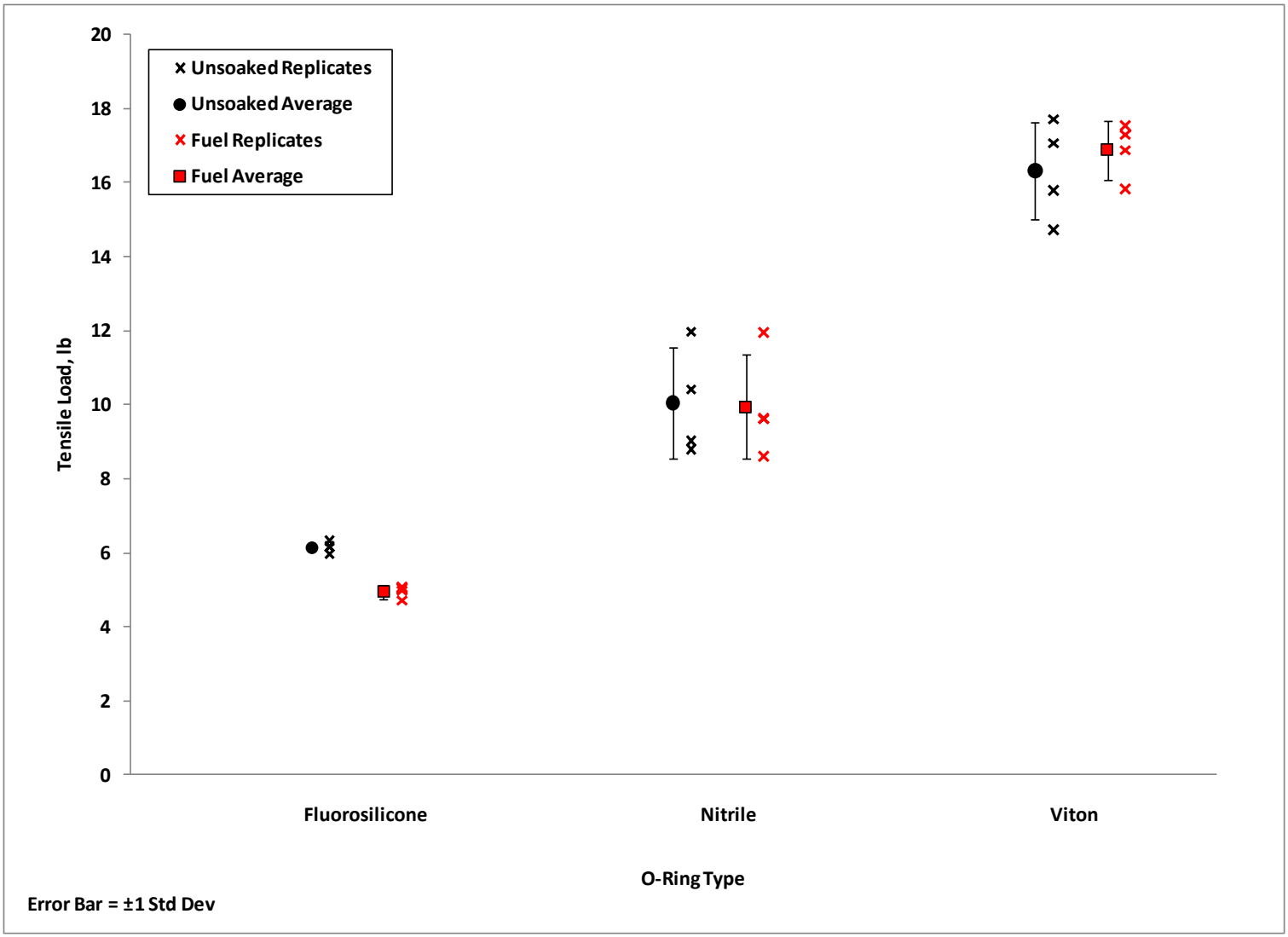

Figure J-2. O-ring Tensile Load – Tallow/JP-8

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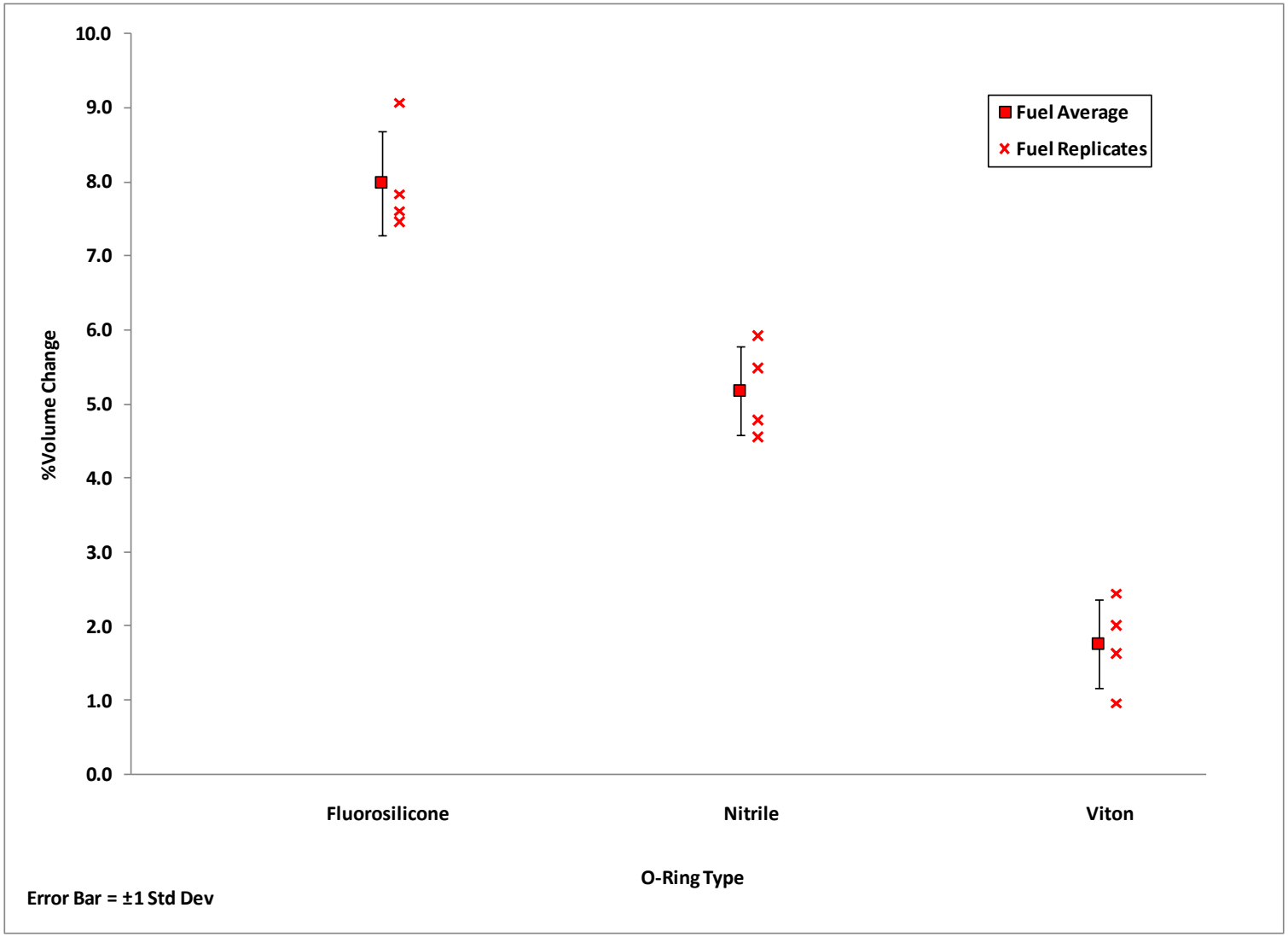

Figure J-3. O-Ring Volume Change – Tallow/JP-8

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Appendix K

EPA Test Data – Camelina and R-8

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Columbia Analytical Services™ 3725 E. Atlanta Avenue, Phoenix, AZ 85040 | 602-437-0330 | www.caslab.com

April 28, 2010

Scott Hutzler
Southwest Research Institute
9503 West Commerce
San Antonio, TX 78227-1301

RE: 14406.05.001
Work Order No.: 10030397

Dear Scott,

Columbia Analytical Services, Inc. received 4 samples on 3/18/10. The results of the analyses are presented in the following report.

The Case Narrative of this report addresses any Quality Control and/or Quality Assurance issues associated with this Work Order.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.caslab.com. All results are intended to be considered in their entirety and Columbia Analytical Services, Inc. (CAS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

If you have any questions regarding these test results, please feel free to call us at: (602) 437-0330.

Sincerely,

Skip Harden
Project Manager

ADHS License No. AZ0133/AZ0667/AZM133

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Columbia Analytical Services

Client: Southwest Research Institute
Work Order: 10030397
Project Name:
Project Number: 14406.05.001

Case Narrative

Results are reported on a wet weight basis unless dry-correction is denoted in the units field on the analytical report ("mg/kg-dry").

All method blanks, laboratory spikes, and/or matrix spikes met quality control objectives for the parameters associated with this Work Order except as detailed below or on the Data Qualifier page of this report. Data Qualifiers used in this report are in accordance with ADEQ Arizona Data Qualifiers, Revision 3.0 9/20/2007.

Data qualifiers ("flags") contained within this analytical report have been issued to explain a quality control deficiency, and do not affect the quality (validity) of the data unless noted otherwise in the case narrative.

The samples were received intact at a temperature of 22.7 degrees C. A valid chain-of-custody was not received.

S10: Analytical Comments for Method SW8260B, Samples 10030397-01 and 03, Batch 5603: The surrogate recovery is above acceptance criteria due to matrix interference.

N1: Analytical Comments for Method SW8270C, LCS/LCSD, Batch 5635: Target analyte recovery was below the default laboratory limits. No historical control limits have been generated yet for LCS/LCSD recoveries.

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CLIENT:	Southwest Research Institute
Project Name:	
Project Number:	14406.05.001
Work Order:	10030397
Date Received:	18-Mar-10

Case Narrative
Data Qualifiers

One or more of the following data qualifiers may be associated with your analytical and/or quality control data.

D1	Sample required dilution due to matrix.
D2	Sample required dilution due to high concentration of target analyte.
L1	The associated blank spike recovery was above laboratory acceptance limits.
L2	The associated blank spike recovery was below laboratory acceptance limits.
M1	Matrix spike recovery was high, the associated blank spike recovery was acceptable.
N1	See case narrative.
Q9	Insufficient sample received to meet method QC requirements.
S10	Surrogate recovery was above laboratory and method acceptance limits. See Case Narrative.
S8	The analysis of the sample required a dilution such that the surrogate recovery calculation does not provide any useful information. The associated blank spike recovery was acceptable.
V1	CCV recovery was above method acceptance limits. This target analyte was not detected in the sample.

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CLIENT: Southwest Research Institute
Project Name:
Project Number: 14406.05.001
Work Order: 10030397

Work Order Sample Summary

Client Sample ID	Lab Sample ID	Test Code	Collection Date	Date Received
CL10-00278	10030397-01A	SW8260B		3/18/10 12:30 PM
		SW8260TIC		3/18/10 12:30 PM
		SW8270C		3/18/10 12:30 PM
		SW8270TIC		3/18/10 12:30 PM
CL10-00327	10030397-02A	SW8260B		3/18/10 12:30 PM
		SW8260TIC		3/18/10 12:30 PM
		SW8270C		3/18/10 12:30 PM
		SW8270TIC		3/18/10 12:30 PM
CL10-00326	10030397-03A	SW8260B		3/18/10 12:30 PM
		SW8260TIC		3/18/10 12:30 PM
		SW8270C		3/18/10 12:30 PM
		SW8270TIC		3/18/10 12:30 PM
CL10-00428	10030397-04A	SW8260B		3/18/10 12:30 PM
		SW8260TIC		3/18/10 12:30 PM
		SW8270C		3/18/10 12:30 PM
		SW8270TIC		3/18/10 12:30 PM

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CLIENT:	Southwest Research Institute
Project Name:	
Project Number:	14406.05.001
Work Order:	10030397
Date Received:	18-Mar-10

References

Columbia Analytical Services, Inc. uses the methods outlined in the following references:

Code of Federal Regulations, 40CFR, Part 136, Appendix A, July 2005.

Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, Revised August 1993.

Methods for the Determination of Metals in Environmental Samples, Supplement 1: EPA/600/R-94/111, Revised May 1994.

Methods for the Determination of Organic Compounds in Drinking Water, EPA/600/4-88/039, Revised July, 1991; EPA-600/4-90/020, Supplement I, July 1990; EPA-600/R-92/129; Supplement II, August 1992; EPA-600/R-95/131, Supplement III, August 1995.

Hach, Water Analysis Handbook, 3rd Edition, 1997.

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition, 1986 including Update I, July 1992; Update IIA, August 1993; Update II; September 1994; Update IIB, January 1995; Update III, December 1996. Update IIIA, June 1999; and Update IIIB July 2005.

Bureau of Laboratory Services, State of Arizona Department of Health Services Method 8015AZ.R1, September 1998. (Comment: C6-C10 GRO reported by this method is not to be used in compliance situations)

ASTM MethodD4982, Annual Book of ASTM Standards, Volumes 11.01 and 11.02, 1995

The Determination of Polychlorinated Biphenyls in Transformer Fluid, and Waste Oils, EPA-600 4-81-045, September 1982.

EPA Method 9013A, Cyanide Extraction Procedure for Solids and Oils. (Rev, 1 November 2004)

EPA Method 5035A, Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples (draft rev. 1 July 2002)

EPA Method 5030C, Purge-and-Trap for Aqueous Samples (rev.3 May 2003)

Office of Ground Water and Drinking Water Technical Support Center, EPA 815-R-05-004, Manual for Certification of Drinking Water, (5th Edition January 2005)

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Columbia Analytical Services™

License No. AZ0133/AZM133

CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00278
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
	TEST METHOD: SW8270C	*PREP METHOD: SW3580A*	*Test Performed By: AZ0133*						
Acenaphthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Acenaphthylene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Anthracene	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Azobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benz[a]anthracene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benzo[a]pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benzo[b]fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benzo[g,h,i]perylene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benzo[k]fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benzoic acid	<74000	74000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Benzyl alcohol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Bis(2-chloroethoxy)methane	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Bis(2-chloroethyl)ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Bis(2-chloroisopropyl)ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Bis(2-ethylhexyl)phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Bromophenyl phenyl ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Butyl benzyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Chloro-3-methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Chloroaniline	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Chloronaphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Chlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Chlorophenyl phenyl ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Chrysene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Di-n-butyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Di-n-octyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Dibenz[a,h]anthracene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Dibenzofuran	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
1,2-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
1,3-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
1,4-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
3,3'-Dichlorobenzidine	<25000	25000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,4-Dichlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Diethyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Dimethyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,4-Dimethylphenol	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4,6-Dinitro-2-methylphenol	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,4-Dinitrophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,4-Dinitrotoluene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,6-Dinitrotoluene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Fluorene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635

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License No. AZ0133/AZM133

CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00278
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Hexachlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Hexachlorobutadiene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Hexachlorocyclopentadiene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Hexachloroethane	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Indeno[1,2,3-cd]pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Isophorone	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Methylnaphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
N-Nitrosodi-n-propylamine	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
N-Nitrosodiphenylamine	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Naphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Nitrobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Nitrophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Nitrophenol	<15000	15000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Pentachlorophenol	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Phenanthrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Phenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
1,2,4-Trichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,4,6-Trichlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Chlorophenol-d4(Surrogate)	0	52-148	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
1,2-Dichlorobenzene-d4(Surrogate)	0	54-148	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Fluorobiphenyl(Surrogate)	0	54-142	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2-Fluorophenol(Surrogate)	0	54-144	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Nitrobenzene-d5(Surrogate)	0	50-151	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
Phenol-d5(Surrogate)	0	51-149	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
4-Terphenyl-d14(Surrogate)	0	58-144	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
2,4,6-Tribromophenol(Surrogate)	0	34-139	S8	%REC	50	3/26/10 7:00	4/1/10 18:49	JH	5635
TEST METHOD: SW8260B	*PREP METHOD: SW5035A*	*Test Performed By: AZ0133*							
Acetone	<74	74	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Benzene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Bromobenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Bromochloromethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Bromodichloromethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Bromoform	<5.0	5.0	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Bromomethane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
2-Butanone	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
n-Butylbenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
sec-Butylbenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
tert-Butylbenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Carbon disulfide	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00278
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Carbon tetrachloride	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Chlorobenzene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Dibromochloromethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Chloroethane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Chloroform	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Chloromethane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
2-Chlorotoluene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
4-Chlorotoluene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2-Dibromo-3-chloropropane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2-Dibromoethane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Dibromomethane	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2-Dichlorobenzene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,3-Dichlorobenzene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,4-Dichlorobenzene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Dichlorodifluoromethane	<25	25	D1,L1,V1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1-Dichloroethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2-Dichloroethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1-Dichloroethene	<5.0	5.0	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
cis-1,2-Dichloroethene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
trans-1,2-Dichloroethene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2-Dichloropropane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,3-Dichloropropane	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
2,2-Dichloropropane	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1-Dichloropropene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
cis-1,3-Dichloropropene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
trans-1,3-Dichloropropene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Ethylbenzene	**50**	5.0	D2	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Hexachlorobutadiene	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
2-Hexanone	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Iodomethane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Isopropylbenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
4-Isopropyltoluene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Methylene chloride	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
4-Methyl-2-pentanone	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Methyl tert-butyl ether	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Naphthalene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
n-Propylbenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Styrene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1,1,2-Tetrachloroethane	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1,2,2-Tetrachloroethane	<5.0	5.0	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Tetrachloroethene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Toluene	<5.0	5.0	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2,3-Trichlorobenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603

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License No. AZ0133/AZM133

CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00278
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
1,2,4-Trichlorobenzene	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1,1-Trichloroethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,1,2-Trichloroethane	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Trichloroethene	<2.5	2.5	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Trichlorofluoromethane	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2,3-Trichloropropane	<12	12	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2,4-Trimethylbenzene	**83**	12	D2	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,3,5-Trimethylbenzene	**54**	12	D2	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Vinyl acetate	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Vinyl chloride	<25	25	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Xylenes, Total	**71**	7.4	D1	mg/Kg	50	3/23/10 11:13	3/24/10 14:56	BK	5603
4-Bromofluorobenzene(Surrogate)	360	62-123	S10	%REC	50	3/23/10 11:13	3/24/10 14:56	BK	5603
1,2-Dichloroethane-d4(Surrogate)	121	54-133		%REC	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Dibromofluoromethane(Surrogate)	158	52-140	S10	%REC	50	3/23/10 11:13	3/24/10 14:56	BK	5603
Toluene-d8(Surrogate)	251	63-126	S10	%REC	50	3/23/10 11:13	3/24/10 14:56	BK	5603

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8260B

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00278
Work Order:	10030397	**Collection Date:**	
LAB ID:	-01A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	111-84-2	Nonane	2500
2.	2847-72-5	4-Methyldecane	14000
3.	62338-14-1	3,3,6-Trimethyldecane	3500
4.	112-95-8	Eicosane	3700
5.	629-50-5	Tridecane	4400
6.	62016-37-9	2,4,6-Trimethyloctane	3700
7.	2980-69-0	4-Methylundecane	4000
8.	2216-33-3	3-Methyloctane	2800
9.	5911-04-6	3-Methylnonane	2200
10.	124-18-5	Decane	8400
11.	64-17-5	Ethanol (present but below quanitation limits)	
12.			
13.			

Values reported for Tentatively Identified Compounds are estimated.

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8270C

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00278
Work Order:	10030397	**Collection Date:**	
LAB ID:	-01A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	3221-61-2	2-Methyloctane	45000
2.	871-83-0	2-Methylnonane	22000
3.	6975-98-0	2-Methyldecane	14000
4.	13151-34-3	3-Methyldecane	13000
5.	17301-94-9	4-Methylnonane	17000
6.	13151-35-4	5-Methyldecane	13000
7.	111-84-2	Nonane	24000
8.	13150-81-7	2,6-Dimethyldecane	14000
9.			
10.			
11.			
12.			
13.			
14.			

Values reported for Tentatively Identified Compounds are estimated.

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-02
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00327
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
	TEST METHOD: SW8270C	*PREP METHOD: SW3550A*	*Test Performed By: AZ0133*						
Acenaphthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Acenaphthylene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Anthracene	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Azobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benz[a]anthracene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benzo[a]pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benzo[b]fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benzo[g,h,i]perylene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benzo[k]fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benzoic acid	<74000	74000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Benzyl alcohol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Bis(2-chloroethoxy)methane	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Bis(2-chloroethyl)ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Bis(2-chloroisopropyl)ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Bis(2-ethylhexyl)phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Bromophenyl phenyl ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Butyl benzyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Chloro-3-methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Chloroaniline	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Chloronaphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Chlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Chlorophenyl phenyl ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Chrysene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Di-n-butyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Di-n-octyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Dibenz[a,h]anthracene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Dibenzofuran	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
1,2-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
1,3-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
1,4-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
3,3'-Dichlorobenzidine	<25000	25000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,4-Dichlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Diethyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Dimethyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,4-Dimethylphenol	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4,6-Dinitro-2-methylphenol	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,4-Dinitrophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,4-Dinitrotoluene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,6-Dinitrotoluene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Fluorene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635

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License No. AZ0133/AZM133

CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-02
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00327
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Hexachlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Hexachlorobutadiene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Hexachlorocyclopentadiene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Hexachloroethane	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Indeno[1,2,3-cd]pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Isophorone	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Methylnaphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
N-Nitrosodi-n-propylamine	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
N-Nitrosodiphenylamine	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Naphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Nitrobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Nitrophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Nitrophenol	<15000	15000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Pentachlorophenol	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Phenanthrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Phenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
1,2,4-Trichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,4,6-Trichlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Chlorophenol-d4(Surrogate)	0	52-148	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
1,2-Dichlorobenzene-d4(Surrogate)	0	54-148	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Fluorobiphenyl(Surrogate)	0	54-142	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2-Fluorophenol(Surrogate)	0	54-144	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Nitrobenzene-d5(Surrogate)	0	50-151	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
Phenol-d6(Surrogate)	0	51-149	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
4-Terphenyl-d14(Surrogate)	0	58-144	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
2,4,6-Tribromophenol(Surrogate)	0	34-139	S8	%REC	50	3/26/10 7:00	4/1/10 19:34	JH	5635
	TEST METHOD: SW8260B		*PREP METHOD: SW5035A*	*Test Performed By: AZ0133*					
Acetone	<1400	1400	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Benzene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Bromobenzene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Bromochloromethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Bromodichloromethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Bromoform	<94	94	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Bromomethane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
2-Butanone	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
n-Butylbenzene	**670**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
sec-Butylbenzene	**620**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
tert-Butylbenzene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Carbon disulfide	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-02
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00327
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Carbon tetrachloride	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Chlorobenzene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Dibromochloromethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Chloroethane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Chloroform	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Chloromethane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
2-Chlorotoluene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
4-Chlorotoluene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2-Dibromo-3-chloropropane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2-Dibromoethane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Dibromomethane	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2-Dichlorobenzene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,3-Dichlorobenzene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,4-Dichlorobenzene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Dichlorodifluoromethane	<470	470	D1,L1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1-Dichloroethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2-Dichloroethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1-Dichloroethene	<94	94	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
cis-1,2-Dichloroethene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
trans-1,2-Dichloroethene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2-Dichloropropane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,3-Dichloropropane	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
2,2-Dichloropropane	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1-Dichloropropane	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
cis-1,3-Dichloropropene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
trans-1,3-Dichloropropene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Ethylbenzene	**620**	94	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Hexachlorobutadiene	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
2-Hexanone	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Iodomethane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Isopropylbenzene	**290**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
4-Isopropyltoluene	**460**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Methylene chloride	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
4-Methyl-2-pentanone	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Methyl tert-butyl ether	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Naphthalene	**550**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
n-Propylbenzene	**740**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Styrene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1,1,2-Tetrachloroethane	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1,2,2-Tetrachloroethane	<94	94	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Tetrachloroethene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Toluene	**610**	94	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2,3-Trichlorobenzene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-02
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00327
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
1,2,4-Trichlorobenzene	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1,1-Trichloroethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,1,2-Trichloroethane	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Trichloroethene	<47	47	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Trichlorofluoromethane	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2,3-Trichloropropane	<240	240	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2,4-Trimethylbenzene	**3600**	470	D2	mg/Kg	1900	3/23/10 11:15	3/23/10 19:21	BK	5603
1,3,5-Trimethylbenzene	**1100**	240	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Vinyl acetate	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Vinyl chloride	<470	470	D1	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Xylenes, Total	**2900**	140	D2	mg/Kg	940	3/23/10 11:15	3/23/10 14:35	BK	5603
4-Bromofluorobenzene(Surrogate)	0	62-123	S8	%REC	940	3/23/10 11:15	3/23/10 14:35	BK	5603
1,2-Dichloroethane-d4(Surrogate)	0	54-133	S8	%REC	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Dibromofluoromethane(Surrogate)	0	52-140	S8	%REC	940	3/23/10 11:15	3/23/10 14:35	BK	5603
Toluene-d8(Surrogate)	0	63-126	S8	%REC	940	3/23/10 11:15	3/23/10 14:35	BK	5603

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8260B

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00327
Work Order:	10030397	**Collection Date:**	
LAB ID:	-02A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	2216-30-0	2,5-Dimethylheptane	6300
2.	15869-89-3	2,5-Dimethyloctane	9300
3.	589-81-1	3-Methylheptane	3900
4.	2216-33-3	3-Methyloctane	16000
5.	5911-04-6	3-Methylnonane	13000
6.	2847-72-5	4-Methyldecane	3800
7.	2980-69-0	4-Methylundecane	3300
8.	563-16-6	3,3-Dimethylhexane	2600
9.	17301-28-9	3,6-Dimethylundecane	3100
10.	1120-21-4	Undecane	9200
11.	112-40-3	Dodecane	6500
12.	629-78-7	Heptadecane	2900
13.	64-17-5	Ethanol	440

Values reported for Tentatively Identified Compounds are estimated.

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8270C

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00327
Work Order:	10030397	**Collection Date:**	
LAB ID:	-02A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	871-83-0	2-Methylnonane	9900
2.	6975-98-0	2-Methyldecane	11000
3.	17301-94-9	4-Methylnonane	10000
4.	2847-72-5	4-Methyldecane	7700
5.	1632-70-8	5-Methylundecane	8000
6.	111-84-2	Nonane	15000
7.	629-50-5	Tridecane	14000
8.	629-59-4	Tetradecane	10000
9.	17301-23-4	2,6-Dimethylundecane	7700
10.	921-47-1	2,3,4-Trimethylhexane	20000
11.			
12.			
13.			
14.			

Values reported for Tentatively Identified Compounds are estimated.

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-03
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00326
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
	TEST METHOD: SW8270C		*PREP METHOD: SW3580A*	*Test Performed By: AZ0133*					
Acenaphthene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Acenaphthylene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Anthracene	<5100	5100	D1,L2	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Azobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benz[a]anthracene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benzo[a]pyrene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benzo[b]fluoranthene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benzo[g,h,i]perylene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benzo[k]fluoranthene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benzoic acid	<76000	76000	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Benzyl alcohol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Bis(2-chloroethoxy)methane	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Bis(2-chloroethyl)ether	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Bis(2-chloroisopropyl)ether	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Bis(2-ethylhexyl)phthalate	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Bromophenyl phenyl ether	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Butyl benzyl phthalate	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Chloro-3-methylphenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Chloroaniline	<10000	10000	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Chloronaphthalene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Chlorophenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Chlorophenyl phenyl ether	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Chrysene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Di-n-butyl phthalate	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Di-n-octyl phthalate	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Dibenz[a,h]anthracene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Dibenzofuran	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
1,2-Dichlorobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
1,3-Dichlorobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
1,4-Dichlorobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
3,3'-Dichlorobenzidine	<25000	25000	D1,L2	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,4-Dichlorophenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Diethyl phthalate	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Dimethyl phthalate	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,4-Dimethylphenol	<5100	5100	D1,L2	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4,6-Dinitro-2-methylphenol	<10000	10000	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,4-Dinitrophenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,4-Dinitrotoluene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,6-Dinitrotoluene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Fluoranthene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Fluorene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-03
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00326
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Hexachlorobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Hexachlorobutadiene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Hexachlorocyclopentadiene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Hexachloroethane	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Indeno[1,2,3-cd]pyrene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Isophorone	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Methylnaphthalene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Methylphenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Methylphenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
N-Nitrosodi-n-propylamine	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
N-Nitrosodiphenylamine	<5100	5100	D1,L2	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Naphthalene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Nitrobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Nitrophenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Nitrophenol	<15000	15000	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Pentachlorophenol	<10000	10000	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Phenanthrene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Phenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Pyrene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
1,2,4-Trichlorobenzene	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,4,6-Trichlorophenol	<5100	5100	D1	mg/Kg	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Chlorophenol-d4(Surrogate)	0	52-148	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
1,2-Dichlorobenzene-d4(Surrogate)	0	54-148	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Fluorobiphenyl(Surrogate)	0	54-142	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2-Fluorophenol(Surrogate)	0	54-144	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Nitrobenzene-d5(Surrogate)	0	50-151	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
Phenol-d6(Surrogate)	0	51-149	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
4-Terphenyl-d14(Surrogate)	0	58-144	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
2,4,6-Tribromophenol(Surrogate)	0	34-139	S8	%REC	51	3/26/10 7:00	4/1/10 20:20	JH	5635
	TEST METHOD: SW8260B		*PREP METHOD: SW5035A*	*Test Performed By: AZ0133*					
Acetone	<71	71	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Benzene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Bromobenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Bromochloromethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Bromodichloromethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Bromoform	<4.8	4.8	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Bromomethane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
2-Butanone	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
n-Butylbenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
sec-Butylbenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
tert-Butylbenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Carbon disulfide	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-03
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00326
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Carbon tetrachloride	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Chlorobenzene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Dibromochloromethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Chloroethane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Chloroform	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Chloromethane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
2-Chlorotoluene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
4-Chlorotoluene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2-Dibromo-3-chloropropane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2-Dibromoethane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Dibromomethane	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2-Dichlorobenzene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,3-Dichlorobenzene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,4-Dichlorobenzene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Dichlorodifluoromethane	<24	24	D1,L1,V1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1-Dichloroethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2-Dichloroethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1-Dichloroethene	<4.8	4.8	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
cis-1,2-Dichloroethene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
trans-1,2-Dichloroethene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2-Dichloropropane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,3-Dichloropropane	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
2,2-Dichloropropane	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1-Dichloropropene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
cis-1,3-Dichloropropene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
trans-1,3-Dichloropropene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Ethylbenzene	**73**	4.8	D2	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Hexachlorobutadiene	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
2-Hexanone	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Iodomethane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Isopropylbenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
4-Isopropyltoluene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Methylene chloride	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
4-Methyl-2-pentanone	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Methyl tert-butyl ether	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Naphthalene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
n-Propylbenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Styrene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1,1,2-Tetrachloroethane	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1,2,2-Tetrachloroethane	<4.8	4.8	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Tetrachloroethene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Toluene	**5.8**	4.8	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2,3-Trichlorobenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-03
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00326
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
1,2,4-Trichlorobenzene	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1,1-Trichloroethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,1,2-Trichloroethane	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Trichloroethene	<2.4	2.4	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Trichlorofluoromethane	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2,3-Trichloropropane	<12	12	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2,4-Trimethylbenzene	**130**	12	D2	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,3,5-Trimethylbenzene	**80**	12	D2	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Vinyl acetate	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Vinyl chloride	<24	24	D1	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Xylenes, Total	**120**	7.1	D2	mg/Kg	48	3/23/10 11:18	3/24/10 15:25	BK	5603
4-Bromofluorobenzene(Surrogate)	559	62-123	S10	%REC	48	3/23/10 11:18	3/24/10 15:25	BK	5603
1,2-Dichloroethane-d4(Surrogate)	112	54-133		%REC	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Dibromofluoromethane(Surrogate)	156	52-140	S10	%REC	48	3/23/10 11:18	3/24/10 15:25	BK	5603
Toluene-d8(Surrogate)	186	63-126	S10	%REC	48	3/23/10 11:18	3/24/10 15:25	BK	5603

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8260B

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00326
Work Order:	10030397	**Collection Date:**	
LAB ID:	-03A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	2216-30-0	2,5-Dimethylheptane	3200
2.	15869-89-3	2,5-Dimethyloctane	6200
3.	2216-33-3	3-Methyloctane	11000
4.	5911-04-6	3-Methylnonane	11000
5.	1002-43-3	3-Methylundecane	3700
6.	13151-34-3	3-Methyldecane	5400
7.	2980-69-0	4-Methylundecane	5400
8.	3221-61-2	2-Methyloctane	17000
9.	13287-21-3	6-Methyltridecane	4200
10.	557-35-7	2-Bromooctane	2500
11.	124-18-5	Decane	8500
12.	629-50-5	Tridecane	7500
13.	111-84-2	Nonane	14000
14.	64-17-5	Ethanol (present but below quanitation limits)	

Values reported for Tentatively Identified Compounds are estimated.

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8270C

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00326
Work Order:	10030397	**Collection Date:**	
LAB ID:	-03A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	871-83-0	2-Methylnonane	10000
2.	6975-98-0	2-Methyldecane	11000
3.	7045-71-8	2-Methylundecane	8700
4.	13151-34-3	3-Methyldecane	11000
5.	17301-94-9	4-Methylnonane	12000
6.	1632-70-8	5-Methylundecane	10000
7.	111-84-2	Nonane	14000
8.	629-50-5	Tridecane	11000
9.	112-40-3	Dodecane	14000
10.	1072-05-5	2,6-Dimethylheptane	14000
11.			
12.			
13.			
14.			

Values reported for Tentatively Identified Compounds are estimated.

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-04
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00428
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
	TEST METHOD: SW8270C	*PREP METHOD: SW3550A*	*Test Performed By: AZ0133*						
Acenaphthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Acenaphthylene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Anthracene	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Azobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benz[a]anthracene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benzo[a]pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benzo[b]fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benzo[g,h,i]perylene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benzo[k]fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benzoic acid	<74000	74000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Benzyl alcohol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Bis(2-chloroethoxy)methane	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Bis(2-chloroethyl)ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Bis(2-chloroisopropyl)ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Bis(2-ethylhexyl)phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Bromophenyl phenyl ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Butyl benzyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Chloro-3-methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Chloroaniline	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Chloronaphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Chlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Chlorophenyl phenyl ether	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Chrysene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Di-n-butyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Di-n-octyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Dibenz[a,h]anthracene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Dibenzofuran	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
1,2-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
1,3-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
1,4-Dichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
3,3'-Dichlorobenzidine	<25000	25000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,4-Dichlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Diethyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Dimethyl phthalate	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,4-Dimethylphenol	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4,6-Dinitro-2-methylphenol	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,4-Dinitrophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,4-Dinitrotoluene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,6-Dinitrotoluene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Fluoranthene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Fluorene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635

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License No. AZ0133/AZM133

CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-04
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00428
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Hexachlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Hexachlorobutadiene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Hexachlorocyclopentadiene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Hexachloroethane	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Indeno[1,2,3-cd]pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Isophorone	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Methylnaphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Methylphenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
N-Nitrosodi-n-propylamine	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
N-Nitrosodiphenylamine	<5000	5000	D1,L2	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Naphthalene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Nitrobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Nitrophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Nitrophenol	<15000	15000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Pentachlorophenol	<9900	9900	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Phenanthrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Phenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Pyrene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
1,2,4-Trichlorobenzene	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,4,6-Trichlorophenol	<5000	5000	D1	mg/Kg	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Chlorophenol-d4(Surrogate)	0	52-148	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
1,2-Dichlorobenzene-d4(Surrogate)	0	54-148	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Fluorobiphenyl(Surrogate)	0	54-142	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2-Fluorophenol(Surrogate)	0	54-144	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Nitrobenzene-d5(Surrogate)	0	50-151	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
Phenol-d6(Surrogate)	0	51-149	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
4-Terphenyl-d14(Surrogate)	0	58-144	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
2,4,6-Tribromophenol(Surrogate)	0	34-139	S8	%REC	50	3/26/10 7:00	4/1/10 21:06	JH	5635
	TEST METHOD: SW8260B		*PREP METHOD: SW5035A*	*Test Performed By: AZ0133*					
Acetone	<1400	1400	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Benzene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Bromobenzene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Bromochloromethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Bromodichloromethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Bromoform	<93	93	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Bromomethane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
2-Butanone	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
n-Butylbenzene	**650**	230	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
sec-Butylbenzene	**670**	230	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
tert-Butylbenzene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Carbon disulfide	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603

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CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-04
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00428
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Carbon tetrachloride	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Chlorobenzene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Dibromochloromethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Chloroethane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Chloroform	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Chloromethane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
2-Chlorotoluene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
4-Chlorotoluene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2-Dibromo-3-chloropropane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2-Dibromoethane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Dibromomethane	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2-Dichlorobenzene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,3-Dichlorobenzene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,4-Dichlorobenzene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Dichlorodifluoromethane	<460	460	D1,L1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1-Dichloroethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2-Dichloroethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1-Dichloroethene	<93	93	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
cis-1,2-Dichloroethene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
trans-1,2-Dichloroethene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2-Dichloropropane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,3-Dichloropropane	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
2,2-Dichloropropane	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1-Dichloropropene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
cis-1,3-Dichloropropene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
trans-1,3-Dichloropropene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Ethylbenzene	**190**	93	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Hexachlorobutadiene	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
2-Hexanone	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Iodomethane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Isopropylbenzene	**260**	230	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
4-Isopropyltoluene	**760**	230	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Methylene chloride	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
4-Methyl-2-pentanone	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Methyl tert-butyl ether	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Naphthalene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
n-Propylbenzene	**600**	230	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Styrene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1,1,2-Tetrachloroethane	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1,2,2-Tetrachloroethane	<93	93	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Tetrachloroethene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Toluene	**140**	93	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2,3-Trichlorobenzene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603

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Columbia Analytical Services

License No. AZ0133/AZM133

CLIENT: Southwest Research Institute
Work Order: 10030397
Lab ID: 10030397-04
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00428
Collection Date:
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
1,2,4-Trichlorobenzene	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1,1-Trichloroethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,1,2-Trichloroethane	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Trichloroethene	<46	46	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Trichlorofluoromethane	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2,3-Trichloropropane	<230	230	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2,4-Trimethylbenzene	**8700**	1200	D2	mg/Kg	4600	3/23/10 11:20	3/25/10 12:29	BK	5603
1,3,5-Trimethylbenzene	**3000**	230	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Vinyl acetate	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Vinyl chloride	<460	460	D1	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Xylenes, Total	**1700**	140	D2	mg/Kg	930	3/23/10 11:20	3/23/10 16:30	BK	5603
4-Bromofluorobenzene(Surrogate)	0	62-123	S8	%REC	930	3/23/10 11:20	3/23/10 16:30	BK	5603
1,2-Dichloroethane-d4(Surrogate)	0	54-133	S8	%REC	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Dibromofluoromethane(Surrogate)	0	52-140	S8	%REC	930	3/23/10 11:20	3/23/10 16:30	BK	5603
Toluene-d8(Surrogate)	0	63-126	S8	%REC	930	3/23/10 11:20	3/23/10 16:30	BK	5603

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8260B

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00428
Work Order:	10030397	**Collection Date:**	
LAB ID:	-04A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	6975-98-0	2-Methyldecane	8000
2.	17312-44-6	2,3-Dimethyldecane	2800
3.	2216-33-3	3-Methyloctane	6800
4.	5911-04-6	3-Methylnonane	8200
5.	2847-72-5	4-Methyldecane	3700
6.	2456-28-2	1,1'-Oxybisdecane	2100
7.	29812-79-1	o-Decylhydroxylamine	10000
8.	112-40-3	Dodecane	5300
9.	1120-21-4	Undecane	9300
10.	111-65-9	Octane	4500
11.	64-17-5	Ethanol	540
12.			
13.			
14.			

Values reported for Tentatively Identified Compounds are estimated.

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8270C

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00428
Work Order:	10030397	**Collection Date:**	
LAB ID:	-04A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	3/23/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	871-83-0	2-Methylnonane	9300
2.	6975-98-0	2-Methyldecane	14000
3.	3221-61-2	2-Methyloctane	8400
4.	13151-34-3	3-Methyldecane	8300
5.	2847-72-5	4-Methyldecane	8900
6.	111-84-2	Nonane	14000
7.	629-50-5	Tridecane	14000
8.	17301-23-4	2,6-Dimethylundecane	8700
9.	15869-89-3	2,5-Dimethyloctane	11000
10.	1678-92-8	propyl-Cyclohexane	8300
11.			
12.			
13.			
14.			

Values reported for Tentatively Identified Compounds are estimated.

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Columbia Analytical Services

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10030397
Project -

MB, LCS, LCSD REPORT

Analyte	MB Result	LCS Result	LCSD Result	Spike Value	LCS REC	LCSD REC	Low - High % Limit	% RPD	RPD Limit	MB Qual	LCS Qual	LCSD Qual	Date Analyzed
					SW8260B								
Batch ID - 5603 Prep Date - 3/23/10 8:30													*Units - mg/Kg*
Acetone	<1.5	1.86	1.92	2.00	93%	96%	52 - 140	3%	23				03/23/10
Benzene	<0.050	1.02	1.05	1.00	102%	105%	70 - 130	3%	20				03/23/10
Bromobenzene	<0.25	1.00	1.04	1.00	100%	104%	70 - 130	4%	20				03/23/10
Bromochloromethane	<0.050	1.04	1.03	1.00	104%	103%	70 - 130	1%	20				03/23/10
Bromodichloromethane	<0.050	0.934	0.952	1.00	93%	95%	70 - 130	2%	20				03/23/10
Bromoform	<0.10	0.815	0.898	1.00	81%	90%	64 - 120	10%	20				03/23/10
Bromomethane	<0.50	1.63	1.41	2.00	81%	71%	21 - 168	14%	56				03/23/10
2-Butanone	<0.50	1.99	2.03	2.00	100%	102%	70 - 133	2%	23				03/23/10
n-Butylbenzene	<0.25	1.05	1.08	1.00	105%	108%	70 - 130	3%	20				03/23/10
sec-Butylbenzene	<0.25	1.09	1.12	1.00	109%	112%	70 - 130	3%	20				03/23/10
tert-Butylbenzene	<0.25	1.06	1.08	1.00	106%	108%	70 - 130	2%	20				03/23/10
Carbon disulfide	<0.50	2.66	2.67	2.00	133%	134%	43 - 164	<1%	38				03/23/10
Carbon tetrachloride	<0.050	0.926	0.953	1.00	93%	95%	70 - 130	3%	20				03/23/10
Chlorobenzene	<0.050	1.04	1.06	1.00	104%	106%	70 - 130	2%	20				03/23/10
Dibromochloromethane	<0.050	0.920	0.935	1.00	92%	94%	70 - 130	2%	20				03/23/10
Chloroethane	<0.50	1.65	1.66	2.00	83%	83%	35 - 156	1%	48				03/23/10
Chloroform	<0.050	0.977	0.983	1.00	98%	98%	70 - 130	1%	20				03/23/10
Chloromethane	<0.50	2.07	2.31	2.00	104%	116%	36 - 153	11%	41				03/23/10
2-Chlorotoluene	<0.25	1.05	1.07	1.00	105%	107%	70 - 130	2%	20				03/23/10
4-Chlorotoluene	<0.25	1.07	1.09	1.00	107%	109%	70 - 130	2%	20				03/23/10
1,2-Dibromo-3-chloropropane	<0.50	0.876	0.926	1.00	88%	93%	64 - 114	6%	20				03/23/10
1,2-Dibromoethane	<0.50	0.986	1.00	1.00	99%	100%	70 - 130	1%	20				03/23/10
Dibromomethane	<0.25	0.998	0.987	1.00	100%	99%	70 - 130	1%	20				03/23/10
1,2-Dichlorobenzene	<0.050	0.982	0.985	1.00	98%	99%	70 - 130	<1%	20				03/23/10
1,3-Dichlorobenzene	<0.050	0.974	1.03	1.00	97%	103%	70 - 130	6%	20				03/23/10
1,4-Dichlorobenzene	<0.050	1.00	0.981	1.00	100%	98%	70 - 130	2%	20				03/23/10
Dichlorodifluoromethane	<0.50	3.45	3.41	2.00	173%	171%	12 - 169	1%	49		L1	L1	03/23/10
1,1-Dichloroethane	<0.050	1.11	1.11	1.00	111%	111%	70 - 130	<1%	20				03/23/10
1,2-Dichloroethane	<0.050	0.909	0.918	1.00	91%	92%	70 - 130	1%	20				03/23/10
1,1-Dichloroethene	<0.10	1.09	1.11	1.00	109%	111%	59 - 126	2%	21				03/23/10
cis-1,2-Dichloroethene	<0.050	1.13	1.13	1.00	113%	113%	70 - 130	<1%	20				03/23/10
trans-1,2-Dichloroethene	<0.050	1.14	1.12	1.00	114%	112%	70 - 130	2%	20				03/23/10
1,2-Dichloropropane	<0.050	0.982	1.01	1.00	98%	101%	70 - 130	3%	20				03/23/10
1,3-Dichloropropane	<0.25	0.970	0.991	1.00	97%	99%	70 - 130	2%	20				03/23/10
2,2-Dichloropropane	<0.25	0.939	0.959	1.00	94%	96%	64 - 123	2%	20				03/23/10
1,1-Dichloropropene	<0.25	0.957	0.988	1.00	96%	99%	70 - 130	3%	20				03/23/10
cis-1,3-Dichloropropene	<0.050	0.955	0.978	1.00	96%	98%	70 - 130	2%	20				03/23/10
trans-1,3-Dichloropropene	<0.050	1.02	1.04	1.00	102%	104%	70 - 130	2%	20				03/23/10
Ethylbenzene	<0.10	0.999	1.04	1.00	100%	104%	70 - 130	4%	20				03/23/10
Hexachlorobutadiene	<0.50	1.00	1.02	1.00	100%	102%	70 - 130	2%	20				03/23/10
2-Hexanone	<0.50	1.78	1.88	2.00	89%	94%	70 - 130	5%	20				03/23/10
Iodomethane	<0.50	1.91	1.71	2.00	96%	86%	53 - 157	11%	31				03/23/10
Isopropylbenzene	<0.25	1.07	1.09	1.00	107%	109%	70 - 130	2%	20				03/23/10
4-Isopropyltoluene	<0.25	1.09	1.13	1.00	109%	113%	70 - 130	4%	20				03/23/10
Methylene chloride	<0.50	1.11	1.12	1.00	111%	112%	70 - 130	1%	20				03/23/10
4-Methyl-2-pentanone	<0.50	1.88	1.93	2.00	94%	97%	70 - 130	3%	20				03/23/10
Methyl tert-butyl ether	<0.25	1.85	1.90	2.00	93%	95%	70 - 130	3%	20				03/23/10
Naphthalene	<0.25	0.958	1.01	1.00	96%	101%	70 - 130	5%	20				03/23/10
n-Propylbenzene	<0.25	1.10	1.11	1.00	110%	111%	70 - 130	1%	20				03/23/10
Styrene	<0.25	1.03	1.05	1.00	103%	105%	70 - 130	2%	20				03/23/10
1,1,1,2-Tetrachloroethane	<0.25	0.937	0.973	1.00	94%	97%	70 - 130	4%	20				03/23/10
1,1,2,2-Tetrachloroethane	<0.10	0.979	0.983	1.00	98%	98%	70 - 130	<1%	20				03/23/10
Tetrachloroethene	<0.050	0.991	1.01	1.00	99%	101%	70 - 130	2%	20				03/23/10

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Columbia Analytical Services

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10030397
Project -

MB, LCS, LCSD REPORT

Analyte	MB Result	LCS Result	LCSD Result	Spike Value	LCS REC	LCSD REC	Low - High % Limit	% RPD	RPD Limit	MB Qual	LCS Qual	LCSD Qual	Date Analyzed
Toluene	<0.10	1.04	1.07	1.00	104%	107%	70 - 130	3%	20				03/23/10
1,2,3-Trichlorobenzene	<0.25	0.951	1.00	1.00	95%	100%	70 - 130	5%	20				03/23/10
1,2,4-Trichlorobenzene	<0.25	0.949	0.987	1.00	95%	99%	70 - 130	4%	20				03/23/10
1,1,1-Trichloroethane	<0.050	0.942	0.961	1.00	94%	96%	70 - 130	2%	20				03/23/10
1,1,2-Trichloroethane	<0.050	1.01	1.03	1.00	101%	103%	70 - 130	2%	20				03/23/10
Trichloroethene	<0.050	0.983	1.01	1.00	98%	101%	70 - 130	3%	20				03/23/10
Trichlorofluoromethane	<0.50	2.17	2.15	2.00	109%	108%	54 - 138	1%	34				03/23/10
1,2,3-Trichloropropane	<0.25	0.975	1.01	1.00	98%	101%	70 - 130	4%	20				03/23/10
1,2,4-Trimethylbenzene	<0.25	1.07	1.10	1.00	107%	110%	70 - 130	3%	20				03/23/10
1,3,5-Trimethylbenzene	<0.25	1.06	1.08	1.00	106%	108%	70 - 130	2%	20				03/23/10
Vinyl acetate	<0.50	1.93	1.99	2.00	97%	100%	22 - 183	3%	20				03/23/10
Vinyl chloride	<0.50	1.82	1.88	2.00	91%	94%	38 - 154	3%	20				03/23/10
Xylenes, Total	<0.15	3.12	3.16	3.00	104%	105%	70 - 130	1%	20				03/23/10
4-Bromofluorobenzene	102%	2.55	2.67	2.50	102%	107%	62 - 123						03/23/10
1,2-Dichloroethane-d4	92%	2.34	2.42	2.50	94%	97%	64 - 133						03/23/10
Dibromofluoromethane	112%	2.78	2.87	2.50	110%	115%	52 - 140						03/23/10
Toluene-d8	111%	2.70	2.83	2.50	108%	113%	63 - 126						03/23/10

SW8270C

Batch ID - 5635 Prep Date - 3/26/10 7:00

Units - mg/Kg

Acenaphthene	<100	125	113	150	83%	75%	70 - 130	10%	20		Q9	Q9	04/01/10
Acenaphthylene	<100	127	116	150	85%	77%	70 - 130	9%	20		Q9	Q9	04/01/10
Anthracene	<100	106	97.5	150	71%	65%	70 - 130	8%	20		Q9	L2,Q9,N1	04/01/10
Azobenzene	<100	163	148	200	81%	74%	70 - 130	10%	20		Q9	Q9	04/01/10
Benz[a]anthracene	<100	122	109	150	81%	73%	70 - 130	11%	20		Q9	Q9	04/01/10
Benzo[a]pyrene	<100	119	108	150	79%	72%	70 - 130	10%	20		Q9	Q9	04/01/10
Benzo[b]fluoranthene	<100	119	108	150	79%	72%	70 - 130	10%	20		Q9	Q9	04/01/10
Benzo[g,h,i]perylene	<100	119	107	150	79%	71%	70 - 130	11%	20		Q9	Q9	04/01/10
Benzo[k]fluoranthene	<100	130	117	150	87%	78%	70 - 130	11%	20		Q9	Q9	04/01/10
Benzoic acid	<1500	617	600	800	103%	100%	70 - 130	3%	20		Q9	Q9	04/01/10
Benzyl alcohol	<100	166	152	200	83%	76%	70 - 130	9%	20		Q9	Q9	04/01/10
Bis(2-chloroethoxy)methane	<100	177	159	200	89%	80%	70 - 130	11%	20		Q9	Q9	04/01/10
Bis(2-chloroethyl)ether	<100	175	162	200	88%	81%	70 - 130	8%	20		Q9	Q9	04/01/10
Bis(2-chloroisopropyl)ether	<100	180	166	200	90%	83%	70 - 130	8%	20		Q9	Q9	04/01/10
Bis(2-ethylhexyl)phthalate	<100	170	152	200	85%	76%	70 - 130	11%	20		Q9	Q9	04/01/10
4-Bromophenyl phenyl ether	<100	196	180	200	98%	90%	70 - 130	9%	20		Q9	Q9	04/01/10
Butyl benzyl phthalate	<100	168	151	200	84%	76%	70 - 130	11%	20		Q9	Q9	04/01/10
4-Chloro-3-methylphenol	<100	323	294	400	81%	74%	70 - 130	9%	20		Q9	Q9	04/01/10
4-Chloroaniline	<200	211	184	200	106%	92%	70 - 130	14%	20		Q9	Q9	04/01/10
2-Chloronaphthalene	<100	166	152	200	83%	76%	70 - 130	9%	20		Q9	Q9	04/01/10
2-Chlorophenol	<100	333	306	400	83%	77%	70 - 130	8%	20		Q9	Q9	04/01/10
4-Chlorophenyl phenyl ether	<100	176	159	200	88%	80%	70 - 130	10%	20		Q9	Q9	04/01/10
Chrysene	<100	124	110	150	83%	73%	70 - 130	12%	20		Q9	Q9	04/01/10
Di-n-butyl phthalate	<100	174	156	200	87%	79%	70 - 130	10%	20		Q9	Q9	04/01/10
Di-n-octyl phthalate	<100	169	154	200	85%	77%	70 - 130	9%	20		Q9	Q9	04/01/10
Dibenz[a,h]anthracene	<100	119	105	150	79%	70%	70 - 130	13%	20		Q9	Q9	04/01/10
Dibenzofuran	<100	165	150	200	83%	75%	70 - 130	10%	20		Q9	Q9	04/01/10
1,2-Dichlorobenzene	<100	164	152	200	82%	76%	70 - 130	8%	20		Q9	Q9	04/01/10
1,3-Dichlorobenzene	<100	166	154	200	83%	77%	70 - 130	8%	20		Q9	Q9	04/01/10
1,4-Dichlorobenzene	<100	168	156	200	84%	78%	70 - 130	7%	20		Q9	Q9	04/01/10
3,3'-Dichlorobenzidine	<500	134	122	200	67%	61%	70 - 130	9%	20		L2,Q9,N1	L2,Q9,N1	04/01/10
2,4-Dichlorophenol	<100	324	297	400	81%	74%	70 - 130	9%	20		Q9	Q9	04/01/10
Diethyl phthalate	<100	179	162	200	90%	81%	70 - 130	10%	20		Q9	Q9	04/01/10
Dimethyl phthalate	<100	175	159	200	88%	80%	70 - 130	10%	20		Q9	Q9	04/01/10
2,4-Dimethylphenol	<100	303	276	400	76%	69%	70 - 130	9%	20		Q9	L2,Q9,N1	04/01/10

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Columbia Analytical Services

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10030397
Project -

MB, LCS, LCSD REPORT

Analyte	MB Result	LCS Result	LCSD Result	Spike Value	LCS REC	LCSD REC	Low - High % Limit	% RPD	RPD Limit	MB Qual	LCS Qual	LCSD Qual	Date Analyzed
4,6-Dinitro-2-methylphenol	<200	382	348	400	96%	87%	70 - 130	9%	20		Q9	Q9	04/01/10
2,4-Dinitrophenol	<100	396	370	400	99%	93%	70 - 130	7%	20		Q9	Q9	04/01/10
2,4-Dinitrotoluene	<100	161	144	200	81%	72%	70 - 130	11%	20		Q9	Q9	04/01/10
2,6-Dinitrotoluene	<100	165	151	200	83%	76%	70 - 130	9%	20		Q9	Q9	04/01/10
Fluoranthene	<100	116	106	150	77%	71%	70 - 130	9%	20		Q9	Q9	04/01/10
Fluorene	<100	123	111	150	82%	74%	70 - 130	10%	20		Q9	Q9	04/01/10
Hexachlorobenzene	<100	164	151	200	82%	76%	70 - 130	8%	20		Q9	Q9	04/01/10
Hexachlorobutadiene	<100	156	141	200	78%	71%	70 - 130	10%	20		Q9	Q9	04/01/10
Hexachlorocyclopentadiene	<100	179	148	200	90%	74%	70 - 130	19%	20		Q9	Q9	04/01/10
Hexachloroethane	<100	167	153	200	84%	77%	70 - 130	9%	20		Q9	Q9	04/01/10
Indeno[1,2,3-cd]pyrene	<100	120	107	150	80%	71%	70 - 130	11%	20		Q9	Q9	04/01/10
Isophorone	<100	157	142	200	79%	71%	70 - 130	10%	20		Q9	Q9	04/01/10
2-Methylnaphthalene	<100	173	157	200	87%	79%	70 - 130	10%	20		Q9	Q9	04/01/10
2-Methylphenol	<100	321	297	400	80%	74%	70 - 130	8%	20		Q9	Q9	04/01/10
4-Methylphenol	<100	350	319	400	88%	80%	70 - 130	9%	20		Q9	Q9	04/01/10
N-Nitrosodi-n-propylamine	<100	187	173	200	94%	87%	70 - 130	8%	20		Q9	Q9	04/01/10
N-Nitrosodiphenylamine	<100	139	127	200	70%	64%	70 - 130	9%	20		Q9	L2,Q9,N1	04/01/10
Naphthalene	<100	127	116	150	85%	77%	70 - 130	9%	20		Q9	Q9	04/01/10
Nitrobenzene	<100	174	158	200	87%	79%	70 - 130	10%	20		Q9	Q9	04/01/10
2-Nitrophenol	<100	310	288	400	78%	72%	70 - 130	7%	20		Q9	Q9	04/01/10
4-Nitrophenol	<300	356	319	400	89%	80%	70 - 130	11%	20		Q9	Q9	04/01/10
Pentachlorophenol	<200	329	305	400	82%	76%	70 - 130	8%	20		Q9	Q9	04/01/10
Phenanthrene	<100	122	111	150	81%	74%	70 - 130	9%	20		Q9	Q9	04/01/10
Phenol	<100	331	302	400	83%	76%	70 - 130	9%	20		Q9	Q9	04/01/10
Pyrene	<100	129	117	150	86%	78%	70 - 130	10%	20		Q9	Q9	04/01/10
1,2,4-Trichlorobenzene	<100	176	161	200	88%	81%	70 - 130	9%	20		Q9	Q9	04/01/10
2,4,6-Trichlorophenol	<100	315	285	400	79%	71%	70 - 130	10%	20		Q9	Q9	04/01/10
2-Chlorophenol-d4	95%	261	240	300	87%	80%	52 - 148						04/01/10
1,2-Dichlorobenzene-d4	98%	176	163	200	88%	81%	54 - 148						04/01/10
2-Fluorobiphenyl	97%	173	157	200	87%	79%	54 - 142						04/01/10
2-Fluorophenol	96%	261	241	300	87%	80%	54 - 144						04/01/10
Nitrobenzene-d5	95%	178	160	200	89%	80%	50 - 151						04/01/10
Phenol-d6	95%	262	238	300	87%	79%	51 - 149						04/01/10
4-Terphenyl-d14	104%	175	157	200	88%	79%	56 - 144						04/01/10
2,4,6-Tribromophenol	53%	243	216	300	81%	72%	34 - 139						04/01/10

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Columbia Analytical Services™

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10030397
Project -

MS, MSD REPORT

Analyte	MS Result	MSD Result	Samp Res	Spike Value	MS REC	MSD REC	Low - High % Limit	% RPD	RPD Limit	MS Qual	MSD Qual	Date Analyzed
				SW8260B								
Batch ID - 5603 Prep Date - 3/23/10 0:17												*Units - mg/Kg*
Parent Sample ID - 10030399-01A												
Acetone	3.89	3.19	<3.0	3.94	99%	80%	49 - 140	20%	35			03/24/10
Benzene	2.23	2.11	<0.099	1.97	113%	106%	63 - 115	6%	22			03/24/10
Bromobenzene	1.97	2.00	<0.50	1.97	100%	100%	57 - 123	2%	25			03/24/10
Bromochloromethane	1.91	1.99	<0.099	1.97	97%	100%	52 - 126	4%	32			03/24/10
Bromodichloromethane	1.94	2.01	<0.099	1.97	98%	101%	57 - 120	4%	22			03/24/10
Bromoform	1.77	1.73	<0.20	1.97	90%	87%	53 - 120	2%	24			03/24/10
Bromomethane	3.18	3.94	<0.99	3.94	81%	99%	25 - 190	21%	54			03/23/10
2-Butanone	4.04	3.59	<0.99	3.94	102%	90%	57 - 137	12%	44			03/24/10
n-Butylbenzene	2.08	2.05	<0.50	1.97	105%	103%	35 - 134	1%	30			03/24/10
sec-Butylbenzene	2.14	2.11	<0.50	1.97	108%	106%	47 - 137	1%	29			03/24/10
tert-Butylbenzene	2.11	2.10	<0.50	1.97	107%	105%	49 - 133	<1%	28			03/24/10
Carbon disulfide	3.63	3.47	<0.99	3.94	92%	87%	26 - 156	5%	40			03/24/10
Carbon tetrachloride	1.89	1.92	<0.099	1.97	96%	96%	47 - 127	13%	26			03/24/10
Chlorobenzene	2.03	2.04	<0.099	1.97	103%	102%	63 - 116	<1%	22			03/24/10
Dibromochloromethane	1.91	1.84	<0.099	1.97	97%	92%	56 - 121	4%	24			03/24/10
Chloroethane	3.54	4.32	<0.99	3.94	90%	108%	32 - 145	20%	51			03/24/10
Chloroform	2.03	2.02	<0.099	1.97	103%	101%	51 - 124	<1%	34			03/24/10
Chloromethane	3.88	3.63	<0.99	3.94	98%	91%	28 - 142	7%	48			03/24/10
2-Chlorotoluene	2.06	2.01	<0.50	1.97	104%	101%	62 - 119	2%	26			03/24/10
4-Chlorotoluene	2.08	2.03	<0.50	1.97	105%	102%	65 - 116	2%	24			03/24/10
1,2-Dibromo-3-chloropropane	1.69	1.66	<0.99	1.97	86%	83%	55 - 116	2%	25			03/24/10
1,2-Dibromoethane	1.96	1.91	<0.99	1.97	99%	96%	58 - 115	3%	22			03/24/10
Dibromomethane	1.94	2.03	<0.50	1.97	98%	102%	59 - 117	5%	23			03/24/10
1,2-Dichlorobenzene	1.84	1.86	<0.099	1.97	93%	93%	62 - 117	1%	23			03/24/10
1,3-Dichlorobenzene	1.95	1.96	<0.099	1.97	99%	98%	61 - 118	1%	24			03/24/10
1,4-Dichlorobenzene	1.83	1.85	<0.099	1.97	93%	93%	64 - 118	1%	23			03/24/10
Dichlorodifluoromethane	4.32	4.34	<0.99	3.94	110%	109%	25 - 143	<1%	62	V1	V1	03/24/10
1,1-Dichloroethane	2.07	2.08	<0.099	1.97	105%	104%	50 - 126	<1%	36			03/24/10
1,2-Dichloroethane	2.05	2.06	<0.099	1.97	104%	103%	56 - 122	<1%	22			03/24/10
1,1-Dichloroethene	1.96	1.89	<0.20	1.97	99%	95%	36 - 131	4%	55			03/24/10
cis-1,2-Dichloroethene	2.04	2.04	<0.099	1.97	103%	102%	46 - 129	<1%	37			03/24/10
trans-1,2-Dichloroethene	2.12	2.11	<0.099	1.97	107%	106%	49 - 127	<1%	38			03/24/10
1,2-Dichloropropane	2.21	2.19	<0.099	1.97	112%	110%	64 - 112	1%	21			03/24/10
1,3-Dichloropropane	2.09	1.96	<0.50	1.97	106%	98%	55 - 117	6%	24			03/24/10
2,2-Dichloropropane	2.26	2.32	<0.50	1.97	115%	116%	41 - 133	3%	32			03/24/10
1,1-Dichloropropene	2.40	2.13	<0.50	1.97	122%	107%	57 - 119	12%	26	M1		03/24/10
cis-1,3-Dichloropropene	2.03	2.00	<0.099	1.97	103%	100%	56 - 115	1%	22			03/24/10
trans-1,3-Dichloropropene	2.01	1.90	<0.099	1.97	102%	95%	59 - 127	6%	22			03/24/10
Ethylbenzene	2.10	2.08	<0.20	1.97	106%	103%	59 - 117	2%	27			03/24/10
Hexachlorobutadiene	1.70	1.78	<0.99	1.97	86%	89%	41 - 148	5%	26			03/24/10
2-Hexanone	3.84	3.53	<0.99	3.94	97%	89%	60 - 128	8%	25			03/24/10
Iodomethane	4.30	4.40	<0.99	3.94	109%	110%	41 - 151	2%	57			03/24/10
Isopropylbenzene	2.00	1.98	<0.50	1.97	101%	99%	58 - 139	1%	29			03/24/10
4-Isopropyltoluene	2.13	2.11	<0.50	1.97	108%	106%	44 - 138	1%	28			03/24/10
Methylene chloride	2.08	2.35	<0.99	1.97	105%	118%	48 - 123	12%	37			03/24/10
4-Methyl-2-pentanone	3.68	3.65	<0.99	3.94	93%	92%	67 - 129	1%	25			03/24/10
Methyl tert-butyl ether	4.94	4.49	<0.50	3.94	125%	113%	62 - 125	10%	24			03/24/10
Naphthalene	1.85	1.78	<0.50	1.97	94%	89%	37 - 138	4%	26			03/24/10
n-Propylbenzene	2.16	2.10	<0.50	1.97	110%	105%	51 - 129	3%	29			03/24/10

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Columbia Analytical Services™

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10030397
Project -

MS, MSD REPORT

Analyte	MS Result	MSD Result	Samp Res	Spike Value	MS REC	MSD REC	Low - High % Limit	% RPD	RPD Limit	MS Qual	MSD Qual	Date Analyzed
Styrene	2.12	2.09	<0.50	1.97	107%	105%	57 - 123	1%	23			03/24/10
1,1,1,2-Tetrachloroethane	1.96	1.95	<0.50	1.97	99%	98%	59 - 115	1%	23			03/24/10
1,1,2,2-Tetrachloroethane	1.79	1.77	<0.20	1.97	91%	89%	45 - 133	1%	29			03/24/10
Tetrachloroethene	2.03	2.01	<0.099	1.97	103%	101%	40 - 125	1%	26			03/24/10
Toluene	2.22	2.22	<0.20	1.97	113%	111%	50 - 125	<1%	28			03/24/10
1,2,3-Trichlorobenzene	1.67	1.63	<0.50	1.97	85%	82%	29 - 135	2%	33			03/24/10
1,2,4-Trichlorobenzene	1.70	1.67	<0.50	1.97	86%	84%	31 - 136	2%	27			03/24/10
1,1,1-Trichloroethane	2.47	2.48	<0.099	1.97	125%	124%	47 - 125	<1%	31			03/24/10
1,1,2-Trichloroethane	2.02	1.97	<0.099	1.97	102%	99%	53 - 117	3%	24			03/24/10
Trichloroethene	2.32	2.18	<0.099	1.97	118%	109%	51 - 130	6%	24			03/24/10
Trichlorofluoromethane	4.05	3.81	<0.99	3.94	103%	96%	36 - 133	6%	45			03/24/10
1,2,3-Trichloropropane	1.93	1.93	<0.50	1.97	98%	97%	56 - 120	<1%	25			03/24/10
1,2,4-Trimethylbenzene	2.09	2.05	<0.50	1.97	106%	103%	49 - 129	2%	38			03/24/10
1,3,5-Trimethylbenzene	2.12	2.09	<0.50	1.97	107%	105%	44 - 137	1%	38			03/24/10
Vinyl acetate	2.83	2.36	<0.99	3.94	72%	59%	25 - 170	18%	50			03/24/10
Vinyl chloride	3.68	3.18	<0.99	3.94	93%	80%	25 - 144	14%	47			03/24/10
Xylenes, Total	6.02	5.9	<0.30	5.92	102%	99%	52 - 126	2%	29			03/24/10
4-Bromofluorobenzene	5.10	5.02		4.93	103%	101%	62 - 123					03/24/10
Dibromofluoromethane	5.34	5.54		4.93	108%	111%	52 - 140					03/24/10
1,2-Dichloroethane-d4	5.27	5.29		4.93	107%	108%	54 - 133					03/24/10
Toluene-d8	5.19	5.54		4.93	105%	111%	63 - 126					03/24/10

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Container type: VOAS

Columbia Analytical Services

Sample Receipt Checklist

Client Name: Southwest Research Institute — Date and Time Received: 3/18/10 1230

Work Order Number: 10030 397 — Checked by: lm

Checklist completed by: Leslie Moby Date: 3/22/10 — Logged In by: lm Date: 3/18/10

Matrix: Liq. Courier Name: Client CAS Fed Ex — Reviewed by: SLr Date: 3/24/10

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	Not Present ☐
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☐	No ☐	
Samples received same day of collection?	Yes ☐	No ☑	Temp: 22.7 Wet Ice Present ☐
Where was the temperature reading taken at?	Sample ☑	Temp Blank ☐	Other:
VOA Water – VOA vials have zero headspace?	Yes ☐	No ☐	N/A ☐
Water – Microbiological bottles have = 2.5 cm headspace?	Yes ☐	No ☐	N/A ☑
Water – All sample pH's acceptable upon receipt?	Yes ☐	No ☐	N/A ☑ Checked by:

If **No**, list all samples and bottle types that are not acceptable in Additional Comments section. Also state any correction actions.

Sulfide Water – Bottles have zero headspace?	Yes ☐	No ☐	N/A ☑	(zero headspace = than neck of bottle)
Dissolved Water Analytes – Field Filtered?	Yes ☐	No ☐	N/A ☑	
Are samples received deemed acceptable?	Yes ☐	No ☑	If **No** then complete section below	

PC Notified Date: ____ Init: ____	PC Init: ____				
Client Notified Date: ____ Init: ____	L/M ☐	Date: ____	L/M ☐	Date: ____	
Contact Name: ____ Action to take:	Analyze ☐	Cancel ☐	Hold ☐	Other:	
Changes/Comments made on original COC?	Yes ☐	N/A ☐	Init: ____	Date: ____	
Changes made in LIMS?	Yes ☐	N/A ☐	Init: ____	Date: ____	

Additional Comments: not at temperature

CS-002-SRChecklist RV4

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Appendix L

EPA Test Data – Tallow

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Trans West Analytical Services

3725 E. Atlanta Avenue, Phoenix, AZ 85040 | 602-437-0330 | www.xenco.com

November 05, 2010

Scott Hutzler
Southwest Research Institute
9503 West Commerce
San Antonio, TX 78227-1301

RE: 14406.05.001
Work Order No.: 10070103

Dear Scott,

XENCO Laboratories, Inc. received 1 sample on 7/08/10. The results of the analyses are presented in the following report.

The Case Narrative of this report addresses any Quality Control and/or Quality Assurance issues associated with this Work Order.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.xenco.com. All results are intended to be considered in their entirety and XENCO Laboratories is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

If you have any questions regarding these test results, please feel free to call us at:
(602) 437-0330.

Sincerely,

Skip Harden
Project Manager

ADHS License No. AZ0757/AZ0758/AZM757

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XENCO Laboratories
Trans West Analytical Services

Client: Southwest Research Institute
Work Order: 10070103
Project Name:
Project Number: 14406.05.001

Case Narrative

Samples were received intact and at a temperature of 24.4 degrees C.

All method blanks, laboratory spikes, and/or matrix spikes met quality control objectives for the parameters associated with this Work Order except as detailed below or on the Data Qualifier page of this report. Data Qualifiers used in this report are in accordance with ADEQ Arizona Data Qualifiers, Revision 3.0 9/20/2007.

Data qualifiers ("flags") contained within this analytical report have been issued to explain a quality control deficiency, and do not affect the quality (validity) of the data unless noted otherwise in the case narrative.

N1: Analytical Comments for Method SW8270C, LCS/LCSD, Batch 6552: MS/MSD was not extracted due to the nature of the sample matrix. If extracted, the spiked MS/MSD sample would require such a dilution that spike compounds would not be detected. The benzoic acid recovery in the LCS was low. No historical control limits have been generated yet for LCS/LCSD recoveries.

N1: Analytical Comments for Method SW8260B, LCS/LCSD, Batch 6551: MS/MSD was not extracted due to the nature of the sample matrix. If extracted, the spiked MS/MSD sample would require such a dilution that spike compounds would not be detected.

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CLIENT:	Southwest Research Institute
Project Name:	
Project Number:	14406.05.001
Work Order:	10070103
Date Received:	08-Jul-10

Case Narrative
Data Qualifiers

One or more of the following data qualifiers may be associated with your analytical and/or quality control data.

D1	Sample required dilution due to matrix.
D2	Sample required dilution due to high concentration of target analyte.
L2	The associated blank spike recovery was below laboratory acceptance limits.
N1	See case narrative.
S8	The analysis of the sample required a dilution such that the surrogate recovery calculation does not provide any useful information. The associated blank spike recovery was acceptable.

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Trans West Analytical Services

License No. AZ0757/AZM757

CLIENT: Southwest Research Institute
Project Name:
Project Number: 14406.05.001
Work Order: 10070103

Work Order Sample Summary

Client Sample ID	Lab Sample ID	Test Code	Collection Date	Date Received
CL10-00932	10070103-01A	SW8260B	7/06/10 12:00 AM	7/08/10 10:25 AM
		SW8260TIC	7/06/10 12:00 AM	7/08/10 10:25 AM
		SW8270C	7/06/10 12:00 AM	7/08/10 10:25 AM
		SW8270TIC	7/06/10 12:00 AM	7/08/10 10:25 AM

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CLIENT:	Southwest Research Institute
Project Name:	
Project Number:	14406.05.001
Work Order:	10070103
Date Received:	08-Jul-10

References

XENCO Laboratories, Inc. uses the methods outlined in the following references:

Code of Federal Regulations, 40CFR, Part 136, Appendix A, July 2005.

Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, Revised August 1993.

Methods for the Determination of Metals in Environmental Samples, Supplement 1: EPA/600/R-94/111, Revised May 1994.

Methods for the Determination of Organic Compounds in Drinking Water, EPA/600/4-88/039, Revised July, 1991; EPA-600/4-90/020, Supplement I, July 1990; EPA-600/R-92/129; Supplement II, August 1992; EPA-600/R-95/131, Supplement III, August 1995.

Hach, Water Analysis Handbook, 3rd Edition, 1997.

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition, 1986 including Update I, July 1992; Update IIA, August 1993; Update II; September 1994; Update IIB, January 1995; Update III, December 1996. Update IIIA, June 1999; and Update IIIB July 2005.

Bureau of Laboratory Services, State of Arizona Department of Health Services Method 8015AZ.R1, September 1998. (Comment: C6-C10 GRO reported by this method is not to be used in compliance situations)

ASTM MethodD4982, Annual Book of ASTM Standards, Volumes 11.01 and 11.02, 1995

The Determination of Polychlorinated Biphenyls in Transformer Fluid and Waste Oils, EPA-600 4-81-045, September 1982.

EPA Method 9013A, Cyanide Extraction Procedure for Solids and Oils. (Rev, 1 November 2004)

EPA Method 5035A, Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples (draft rev. 1 July 2002)

EPA Method 5030C, Purge-and-Trap for Aqueous Samples (rev.3 May 2003)

Office of Ground Water and Drinking Water Technical Support Center, EPA 815-R-05-004, Manual for Certification of Drinking Water, (5th Edition January 2005)

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CLIENT: Southwest Research Institute
Work Order: 10070103
Lab ID: 10070103-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00932
Collection Date: 7/6/2010
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
	TEST METHOD: SW8270C		*PREP METHOD: SW3580A*		*Test Performed By: AZ0757*				
Acenaphthene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Acenaphthylene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Anthracene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Azobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benz[a]anthracene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benzo[a]pyrene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benzo[b]fluoranthene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benzo[g,h,i]perylene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benzo[k]fluoranthene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benzoic acid	<30000	30000	L2,D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Benzyl alcohol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Bis(2-chloroethoxy)methane	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Bis(2-chloroethyl)ether	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Bis(2-chloroisopropyl)ether	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Bis(2-ethylhexyl)phthalate	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Bromophenyl phenyl ether	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Butyl benzyl phthalate	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Chloro-3-methylphenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Chloroaniline	<4000	4000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Chloronaphthalene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Chlorophenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Chlorophenyl phenyl ether	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Chrysene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Di-n-butyl phthalate	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Di-n-octyl phthalate	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Dibenz[a,h]anthracene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Dibenzofuran	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
1,2-Dichlorobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
1,3-Dichlorobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
1,4-Dichlorobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
3,3'-Dichlorobenzidine	<10000	10000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,4-Dichlorophenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Diethyl phthalate	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Dimethyl phthalate	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,4-Dimethylphenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4,6-Dinitro-2-methylphenol	<4000	4000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,4-Dinitrophenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,4-Dinitrotoluene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,6-Dinitrotoluene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552

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CLIENT: Southwest Research Institute
Work Order: 10070103
Lab ID: 10070103-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00932
Collection Date: 7/6/2010
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Fluoranthene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Fluorene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Hexachlorobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Hexachlorobutadiene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Hexachlorocyclopentadiene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Hexachloroethane	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Indeno[1,2,3-cd]pyrene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Isophorone	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Methylnaphthalene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Methylphenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Methylphenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
N-Nitrosodi-n-propylamine	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
N-Nitrosodiphenylamine	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Naphthalene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Nitrobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Nitrophenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Nitrophenol	<6000	6000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Pentachlorophenol	<4000	4000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Phenanthrene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Phenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Pyrene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
1,2,4-Trichlorobenzene	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,4,6-Trichlorophenol	<2000	2000	D1	mg/Kg	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Chlorophenol-d4(Surrogate)	0	52-148	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
1,2-Dichlorobenzene-d4(Surrogate)	0	54-148	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Fluorobiphenyl(Surrogate)	0	54-142	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2-Fluorophenol(Surrogate)	0	54-144	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Nitrobenzene-d5(Surrogate)	0	50-151	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
Phenol-d6(Surrogate)	0	51-149	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
4-Terphenyl-d14(Surrogate)	0	58-144	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
2,4,6-Tribromophenol(Surrogate)	0	34-139	S8	%REC	20	7/15/10 15:40	7/20/10 21:29	JH	6552
	TEST METHOD: SW8260B		***PREP METHOD: SW5035A***		***Test Performed By: AZ0757***				
Acetone	<1400	1400	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Benzene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Bromobenzene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Bromochloromethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Bromodichloromethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Bromoform	<93	93	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Bromomethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
2-Butanone	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551

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CLIENT: Southwest Research Institute
Work Order: 10070103
Lab ID: 10070103-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00932
Collection Date: 7/6/2010
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
n-Butylbenzene	**570**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
sec-Butylbenzene	**500**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
tert-Butylbenzene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Carbon disulfide	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Carbon tetrachloride	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Chlorobenzene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Dibromochloromethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Chloroethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Chloroform	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Chloromethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
2-Chlorotoluene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
4-Chlorotoluene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2-Dibromo-3-chloropropane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2-Dibromoethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Dibromomethane	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2-Dichlorobenzene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,3-Dichlorobenzene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,4-Dichlorobenzene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Dichlorodifluoromethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1-Dichloroethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2-Dichloroethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1-Dichloroethene	<93	93	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
cis-1,2-Dichloroethene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
trans-1,2-Dichloroethene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2-Dichloropropane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,3-Dichloropropane	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
2,2-Dichloropropane	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1-Dichloropropene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
cis-1,3-Dichloropropene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
trans-1,3-Dichloropropene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Ethylbenzene	**540**	93	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Hexachlorobutadiene	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
2-Hexanone	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Iodomethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Isopropylbenzene	**260**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
4-Isopropyltoluene	**370**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Methylene chloride	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
4-Methyl-2-pentanone	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Methyl tert-butyl ether	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Naphthalene	**590**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
n-Propylbenzene	**580**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551

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License No. AZ0757/AZM757

CLIENT: Southwest Research Institute
Work Order: 10070103
Lab ID: 10070103-01
Project Name:
Project Number: 14406.05.001

Client Sample ID: CL10-00932
Collection Date: 7/6/2010
Matrix: Liquid

Analyte	Result	PQL	Qual	Units	DF	Date Prepared	Date Analyzed	Analyst	Batch ID
Styrene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1,1,2-Tetrachloroethane	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1,2,2-Tetrachloroethane	<93	93	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Tetrachloroethene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Toluene	**520**	93	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2,3-Trichlorobenzene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2,4-Trichlorobenzene	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1,1-Trichloroethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,1,2-Trichloroethane	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Trichloroethene	<47	47	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Trichlorofluoromethane	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2,3-Trichloropropane	<230	230	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2,4-Trimethylbenzene	**3500**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,3,5-Trimethylbenzene	**710**	230	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Vinyl acetate	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Vinyl chloride	<470	470	D1	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Xylenes, Total	**2400**	140	D2	mg/Kg	930	7/15/10 14:35	7/19/10 18:48	RH	6551
4-Bromofluorobenzene(Surrogate)	0	62-123	S8	%REC	930	7/15/10 14:35	7/19/10 18:48	RH	6551
1,2-Dichloroethane-d4(Surrogate)	0	54-133	S8	%REC	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Dibromofluoromethane(Surrogate)	0	52-140	S8	%REC	930	7/15/10 14:35	7/19/10 18:48	RH	6551
Toluene-d8(Surrogate)	0	63-126	S8	%REC	930	7/15/10 14:35	7/19/10 18:48	RH	6551

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8260B

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00932
Work Order:	10070103	**Collection Date:**	
LAB ID:	-01A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	07/19/10

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	6008-81-7	2-ethyl-2-methyl-1, 3-ditholane	1400
2.	135-98-8	(1-Methylpropyl)benzene	1400
3.	874-41-9	1-Ethyl-2,3-dimethylbenzene	1400
4.	135-01-3	1,2-Diethylbenzene	3700
5.	15869-89-3	2,5-Dimethyloctane	1400
6.	2216-33-3	3-Methyloctane	4400
7.	5911-04-6	3-Methylnonane	2200
8.	17453-93-9	5-Methyldodecane	7100
9.	111-65-9	Octane	2100
10.	111-84-2	Nonane	4200
11.	124-18-5	Decane	2500
12.			
13.			

Values reported for Tentatively Identified Compounds are estimated.

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TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 8270C

CLIENT:	**Southwest Research Institute**	**Client Sample ID:**	CL10-00932
Work Order:	10070103	**Collection Date:**	
LAB ID:	-01A	**Matrix:**	Liquid
Project Name:		**Date Prepared:**	
Project Number:	14406.05.001	**Date Analyzed:**	07/20/2010

No.	CAS #	Compound Name	Amount (mg/Kg)
1.	111-84-2	Nonane	1300
2.	1112-40-3	Dodecane	1900
3.	626-59-4	Tetradecane	1900
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			

Values reported for Tentatively Identified Compounds are estimated.

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XENCO Laboratories
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QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10070103
Project -

MB, LCS, LCSD REPORT

Analyte	MB Result	LCS Result	LCSD Result	Spike Value	LCS REC	LCSD REC	Low - High % Limit	% RPD	RPD Limit	MB Qual	LCS Qual	LCSD Qual	Date Analyzed
					SW8260B								
Batch ID - 6551 Prep Date - 7/15/10 14:32													***Units - mg/Kg***
Acetone	<1.5	2.11	2.11	2.00	106%	106%	52 - 140	<1%	23		N1	N1	07/16/10
Benzene	<0.050	0.902	0.884	1.00	90%	88%	70 - 130	2%	20		N1	N1	07/16/10
Bromobenzene	<0.25	0.971	0.959	1.00	97%	96%	70 - 130	1%	20		N1	N1	07/16/10
Bromochloromethane	<0.050	0.852	0.858	1.00	85%	86%	70 - 130	1%	20		N1	N1	07/16/10
Bromodichloromethane	<0.050	1.01	0.985	1.00	101%	99%	70 - 130	3%	20		N1	N1	07/16/10
Bromoform	<0.10	1.02	1.02	1.00	102%	102%	64 - 120	<1%	20		N1	N1	07/16/10
Bromomethane	<0.50	1.17	1.26	2.00	59%	63%	21 - 168	7%	58		N1	N1	07/16/10
2-Butanone	<0.50	2.16	2.13	2.00	108%	107%	70 - 133	1%	23		N1	N1	07/16/10
n-Butylbenzene	<0.25	0.973	0.938	1.00	97%	94%	70 - 130	4%	20		N1	N1	07/16/10
sec-Butylbenzene	<0.25	0.979	0.963	1.00	98%	96%	70 - 130	2%	20		N1	N1	07/16/10
tert-Butylbenzene	<0.25	0.985	0.939	1.00	99%	94%	70 - 130	5%	20		N1	N1	07/16/10
Carbon disulfide	<0.50	1.55	1.48	2.00	78%	74%	43 - 164	5%	38		N1	N1	07/16/10
Carbon tetrachloride	<0.050	0.982	0.962	1.00	98%	96%	70 - 130	2%	20		N1	N1	07/16/10
Chlorobenzene	<0.050	0.972	0.948	1.00	97%	95%	70 - 130	3%	20		N1	N1	07/16/10
Dibromochloromethane	<0.050	1.02	1.00	1.00	102%	100%	70 - 130	2%	20		N1	N1	07/16/10
Chloroethane	<0.50	1.32	1.37	2.00	66%	69%	35 - 156	4%	48		N1	N1	07/16/10
Chloroform	<0.050	0.920	0.903	1.00	92%	90%	70 - 130	2%	20		N1	N1	07/16/10
Chloromethane	<0.50	1.68	1.91	2.00	84%	96%	36 - 153	13%	41		N1	N1	07/16/10
2-Chlorotoluene	<0.25	0.966	0.974	1.00	97%	97%	70 - 130	1%	20		N1	N1	07/16/10
4-Chlorotoluene	<0.25	1.02	1.00	1.00	102%	100%	70 - 130	2%	20		N1	N1	07/16/10
1,2-Dibromo-3-chloropropane	<0.50	1.06	1.09	1.00	106%	109%	64 - 114	3%	20		N1	N1	07/16/10
1,2-Dibromoethane	<0.50	0.987	0.986	1.00	99%	99%	70 - 130	<1%	20		N1	N1	07/16/10
Dibromomethane	<0.25	0.991	0.956	1.00	99%	96%	70 - 130	4%	20		N1	N1	07/16/10
1,2-Dichlorobenzene	<0.050	0.940	0.921	1.00	94%	92%	70 - 130	2%	20		N1	N1	07/16/10
1,3-Dichlorobenzene	<0.050	0.952	0.926	1.00	95%	93%	70 - 130	3%	20		N1	N1	07/16/10
1,4-Dichlorobenzene	<0.050	0.952	0.943	1.00	95%	94%	70 - 130	1%	20		N1	N1	07/16/10
Dichlorodifluoromethane	<0.50	1.44	1.50	2.00	72%	75%	12 - 169	4%	49		N1	N1	07/16/10
1,1-Dichloroethane	<0.050	0.899	0.873	1.00	90%	87%	70 - 130	3%	20		N1	N1	07/16/10
1,2-Dichloroethane	<0.050	0.995	0.962	1.00	100%	96%	70 - 130	3%	20		N1	N1	07/16/10
1,1-Dichloroethene	<0.10	0.775	0.741	1.00	78%	74%	59 - 126	4%	21		N1	N1	07/16/10
cis-1,2-Dichloroethene	<0.050	0.915	0.880	1.00	92%	88%	70 - 130	4%	20		N1	N1	07/16/10
trans-1,2-Dichloroethene	<0.050	0.881	0.851	1.00	88%	85%	70 - 130	3%	20		N1	N1	07/16/10
1,2-Dichloropropane	<0.050	0.974	0.963	1.00	97%	96%	70 - 130	1%	20		N1	N1	07/16/10
1,3-Dichloropropane	<0.25	0.984	0.968	1.00	98%	97%	70 - 130	2%	20		N1	N1	07/16/10
2,2-Dichloropropane	<0.25	0.984	0.931	1.00	98%	93%	64 - 123	6%	20		N1	N1	07/16/10
1,1-Dichloropropene	<0.25	0.941	0.922	1.00	94%	92%	70 - 130	2%	20		N1	N1	07/16/10
cis-1,3-Dichloropropene	<0.050	0.965	0.938	1.00	97%	94%	70 - 130	3%	20		N1	N1	07/16/10
trans-1,3-Dichloropropene	<0.050	1.18	1.13	1.00	118%	113%	70 - 130	4%	20		N1	N1	07/16/10
Ethylbenzene	<0.10	0.982	0.953	1.00	98%	95%	70 - 130	3%	20		N1	N1	07/16/10
Hexachlorobutadiene	<0.50	0.963	0.941	1.00	96%	94%	70 - 130	2%	20		N1	N1	07/16/10
2-Hexanone	<0.50	2.25	2.27	2.00	113%	114%	70 - 130	1%	20		N1	N1	07/16/10
Iodomethane	<0.50	1.39	1.30	2.00	70%	65%	53 - 157	7%	31		N1	N1	07/16/10
Isopropylbenzene	<0.25	1.05	1.02	1.00	105%	102%	70 - 130	3%	20		N1	N1	07/16/10
4-Isopropyltoluene	<0.25	1.01	0.993	1.00	101%	99%	70 - 130	2%	20		N1	N1	07/16/10
Methylene chloride	<0.50	0.891	0.866	1.00	89%	87%	70 - 130	3%	20		N1	N1	07/16/10
4-Methyl-2-pentanone	<0.50	2.20	2.22	2.00	110%	111%	70 - 130	1%	20		N1	N1	07/16/10
Methyl tert-butyl ether	<0.25	2.03	1.96	2.00	102%	98%	70 - 130	4%	20		N1	N1	07/16/10
Naphthalene	<0.25	0.991	1.01	1.00	99%	101%	70 - 130	2%	20		N1	N1	07/16/10

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Trans West Analytical Services

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10070103
Project -

MB, LCS, LCSD REPORT

Analyte	MB Result	LCS Result	LCSD Result	Spike Value	LCS REC	LCSD REC	Low - High % Limit	% RPD	RPD Limit	MB Qual	LCS Qual	LCSD Qual	Date Analyzed
n-Propylbenzene	<0.25	1.01	0.992	1.00	101%	99%	70 - 130	2%	20		N1	N1	07/16/10
Styrene	<0.25	1.00	0.985	1.00	100%	99%	70 - 130	2%	20		N1	N1	07/16/10
1,1,1,2-Tetrachloroethane	<0.25	0.991	0.957	1.00	99%	96%	70 - 130	3%	20		N1	N1	07/16/10
1,1,2,2-Tetrachloroethane	<0.10	1.05	1.05	1.00	105%	105%	70 - 130	<1%	20		N1	N1	07/16/10
Tetrachloroethene	<0.050	0.973	0.968	1.00	97%	97%	70 - 130	1%	20		N1	N1	07/16/10
Toluene	<0.10	0.941	0.924	1.00	94%	92%	70 - 130	2%	20		N1	N1	07/16/10
1,2,3-Trichlorobenzene	<0.25	0.940	0.898	1.00	94%	90%	70 - 130	5%	20		N1	N1	07/16/10
1,2,4-Trichlorobenzene	<0.25	0.928	0.914	1.00	93%	91%	70 - 130	2%	20		N1	N1	07/16/10
1,1,1-Trichloroethane	<0.050	0.899	0.938	1.00	90%	94%	70 - 130	4%	20		N1	N1	07/16/10
1,1,2-Trichloroethane	<0.050	1.02	0.973	1.00	102%	97%	70 - 130	5%	20		N1	N1	07/16/10
Trichloroethene	<0.050	0.932	0.935	1.00	93%	94%	70 - 130	<1%	20		N1	N1	07/16/10
Trichlorofluoromethane	<0.50	1.55	1.61	2.00	78%	81%	54 - 136	4%	34		N1	N1	07/16/10
1,2,3-Trichloropropane	<0.25	1.01	1.04	1.00	101%	104%	70 - 130	3%	20		N1	N1	07/16/10
1,2,4-Trimethylbenzene	<0.25	0.994	0.932	1.00	99%	93%	70 - 130	6%	20		N1	N1	07/16/10
1,3,5-Trimethylbenzene	<0.25	0.942	0.966	1.00	94%	97%	70 - 130	3%	20		N1	N1	07/16/10
Vinyl acetate	<0.50	2.18	2.14	2.00	109%	107%	22 - 183	2%	20		N1	N1	07/16/10
Vinyl chloride	<0.50	1.78	1.90	2.00	89%	95%	38 - 154	7%	20		N1	N1	07/16/10
Xylenes, Total	<0.15	2.902	2.851	3.00	97%	95%	70 - 130	1%	20		N1	N1	07/16/10
4-Bromofluorobenzene	95%	2.30	2.20	2.50	92%	88%	62 - 123						07/16/10
1,2-Dichloroethane-d4	98%	2.00	1.92	2.50	80%	77%	54 - 133						07/16/10
Dibromofluoromethane	91%	1.91	1.85	2.50	76%	74%	52 - 140						07/16/10
Toluene-d8	94%	1.97	1.89	2.50	79%	76%	63 - 126						07/16/10

SW8270C

Batch ID - 6552 Prep Date - 7/15/10 15:40 ***Units - mg/Kg***

Acenaphthene	<100	147	150	150	98%	100%	70 - 130	2%	20		N1	N1	07/15/10
Acenaphthylene	<100	149	152	150	99%	101%	70 - 130	2%	20		N1	N1	07/15/10
Anthracene	<100	144	146	150	96%	97%	70 - 130	1%	20		N1	N1	07/15/10
Azobenzene	<100	220	224	200	110%	112%	70 - 130	2%	20		N1	N1	07/15/10
Benz[a]anthracene	<100	149	151	150	99%	101%	70 - 130	1%	20		N1	N1	07/15/10
Benzo[a]pyrene	<100	144	146	150	96%	97%	70 - 130	1%	20		N1	N1	07/15/10
Benzo[b]fluoranthene	<100	139	139	150	93%	93%	70 - 130	<1%	20		N1	N1	07/15/10
Benzo[g,h,i]perylene	<100	143	145	150	95%	97%	70 - 130	1%	20		N1	N1	07/15/10
Benzo[k]fluoranthene	<100	158	164	150	105%	109%	70 - 130	4%	20		N1	N1	07/15/10
Benzoic acid	<1500	404	415	600	67%	69%	70 - 130	3%	20		L2,N1	N1	07/15/10
Benzyl alcohol	<100	188	189	200	94%	95%	70 - 130	1%	20		N1	L2,N1	07/15/10
Bis(2-chloroethoxy)methane	<100	199	202	200	100%	101%	70 - 130	1%	20		N1	N1	07/15/10
Bis(2-chloroethyl)ether	<100	191	194	200	96%	97%	70 - 130	2%	20		N1	N1	07/15/10
Bis(2-chloroisopropyl)ether	<100	206	207	200	103%	104%	70 - 130	<1%	20		N1	N1	07/15/10
Bis(2-ethylhexyl)phthalate	<100	226	226	200	113%	113%	70 - 130	<1%	20		N1	N1	07/15/10
4-Bromophenyl phenyl ether	<100	200	203	200	100%	102%	70 - 130	1%	20		N1	N1	07/15/10
Butyl benzyl phthalate	<100	194	196	200	97%	98%	70 - 130	1%	20		N1	N1	07/15/10
4-Chloro-3-methylphenol	<100	398	401	400	100%	100%	70 - 130	1%	20		N1	N1	07/15/10
4-Chloroaniline	<200	194	196	200	97%	98%	70 - 130	1%	20		N1	N1	07/15/10
2-Chloronaphthalene	<100	196	202	200	98%	101%	70 - 130	3%	20		N1	N1	07/15/10
2-Chlorophenol	<100	387	389	400	97%	97%	70 - 130	1%	20		N1	N1	07/15/10
4-Chlorophenyl phenyl ether	<100	204	203	200	102%	102%	70 - 130	<1%	20		N1	N1	07/15/10
Chrysene	<100	147	149	150	98%	99%	70 - 130	1%	20		N1	N1	07/15/10
Di-n-butyl phthalate	<100	203	205	200	102%	103%	70 - 130	1%	20		N1	N1	07/15/10
Di-n-octyl phthalate	<100	208	208	200	104%	104%	70 - 130	<1%	20		N1	N1	07/15/10

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XENCO Laboratories
Trans West Analytical Services

QC SUMMARY REPORT

Client - Southwest Research Institute
Work Order - 10070103
Project -

MB, LCS, LCSD REPORT

Analyte	MB Result	LCS Result	LCSD Result	Spike Value	LCS REC	LCSD REC	Low - High % Limit	% RPD	RPD Limit	MB Qual	LCS Qual	LCSD Qual	Date Analyzed
Dibenz[a,h]anthracene	<100	143	146	150	95%	97%	70 - 130	2%	20		N1	N1	07/15/10
Dibenzofuran	<100	198	204	200	99%	102%	70 - 130	3%	20		N1	N1	07/15/10
1,2-Dichlorobenzene	<100	196	201	200	98%	101%	70 - 130	3%	20		N1	N1	07/15/10
1,3-Dichlorobenzene	<100	195	197	200	98%	99%	70 - 130	1%	20		N1	N1	07/15/10
1,4-Dichlorobenzene	<100	202	204	200	101%	102%	70 - 130	1%	20		N1	N1	07/15/10
3,3`-Dichlorobenzidine	<500	155	158	200	78%	79%	70 - 130	2%	20		N1	N1	07/15/10
2,4-Dichlorophenol	<100	399	399	400	100%	100%	70 - 130	<1%	20		N1	N1	07/15/10
Diethyl phthalate	<100	204	208	200	102%	104%	70 - 130	2%	20		N1	N1	07/15/10
Dimethyl phthalate	<100	196	198	200	98%	99%	70 - 130	1%	20		N1	N1	07/15/10
2,4-Dimethylphenol	<100	352	356	400	88%	89%	70 - 130	1%	20		N1	N1	07/15/10
4,6-Dinitro-2-methylphenol	<200	386	395	400	97%	99%	70 - 130	2%	20		N1	N1	07/15/10
2,4-Dinitrophenol	<100	369	374	400	92%	94%	70 - 130	1%	20		N1	N1	07/15/10
2,4-Dinitrotoluene	<100	203	204	200	102%	102%	70 - 130	<1%	20		N1	N1	07/15/10
2,6-Dinitrotoluene	<100	196	202	200	98%	101%	70 - 130	3%	20		N1	N1	07/15/10
Fluoranthene	<100	141	144	150	94%	96%	70 - 130	2%	20		N1	N1	07/15/10
Fluorene	<100	154	156	150	103%	104%	70 - 130	1%	20		N1	N1	07/15/10
Hexachlorobenzene	<100	205	207	200	103%	104%	70 - 130	1%	20		N1	N1	07/15/10
Hexachlorobutadiene	<100	191	195	200	96%	98%	70 - 130	2%	20		N1	N1	07/15/10
Hexachlorocyclopentadiene	<100	171	178	200	86%	89%	70 - 130	4%	20		N1	N1	07/15/10
Hexachloroethane	<100	208	210	200	104%	105%	70 - 130	1%	20		N1	N1	07/15/10
Indeno[1,2,3-cd]pyrene	<100	143	146	150	95%	97%	70 - 130	2%	20		N1	N1	07/15/10
Isophorone	<100	181	182	200	91%	91%	70 - 130	1%	20		N1	N1	07/15/10
2-Methylnaphthalene	<100	205	207	200	103%	104%	70 - 130	1%	20		N1	N1	07/15/10
2-Methylphenol	<100	398	396	400	100%	99%	70 - 130	1%	20		N1	N1	07/15/10
4-Methylphenol	<100	415	417	400	104%	104%	70 - 130	<1%	20		N1	N1	07/15/10
N-Nitrosodi-n-propylamine	<100	212	215	200	106%	108%	70 - 130	1%	20		N1	N1	07/15/10
N-Nitrosodiphenylamine	<100	144	150	200	72%	75%	70 - 130	4%	20		N1	N1	07/15/10
Naphthalene	<100	153	152	150	102%	101%	70 - 130	1%	20		N1	N1	07/15/10
Nitrobenzene	<100	209	208	200	105%	104%	70 - 130	<1%	20		N1	N1	07/15/10
2-Nitrophenol	<100	379	387	400	95%	97%	70 - 130	2%	20		N1	N1	07/15/10
4-Nitrophenol	<300	377	395	400	94%	99%	70 - 130	5%	20		N1	N1	07/15/10
Pentachlorophenol	<200	282	284	400	71%	71%	70 - 130	1%	20		N1	N1	07/15/10
Phenanthrene	<100	151	152	150	101%	101%	70 - 130	1%	20		N1	N1	07/15/10
Phenol	<100	378	384	400	95%	96%	70 - 130	2%	20		N1	N1	07/15/10
Pyrene	<100	145	148	150	97%	99%	70 - 130	2%	20		N1	N1	07/15/10
1,2,4-Trichlorobenzene	<100	212	209	200	106%	105%	70 - 130	1%	20		N1	N1	07/15/10
2,4,6-Trichlorophenol	<100	370	378	400	93%	95%	70 - 130	2%	20		N1	N1	07/15/10
2-Chlorophenol-d4	97%	294	295	300	98%	98%	52 - 148						07/15/10
1,2-Dichlorobenzene-d4	99%	197	197	200	99%	99%	54 - 148						07/15/10
2-Fluorobiphenyl	101%	197	198	200	99%	99%	54 - 142						07/15/10
2-Fluorophenol	94%	282	280	300	94%	93%	54 - 144						07/15/10
Nitrobenzene-d5	101%	203	205	200	102%	103%	50 - 151						07/15/10
Phenol-d6	96%	291	292	300	97%	97%	51 - 149						07/15/10
4-Terphenyl-d14	87%	164	166	200	82%	83%	58 - 144						07/15/10
2,4,6-Tribromophenol	78%	278	281	300	93%	94%	34 - 139						07/15/10

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10070130 (lh)
10070103

SOUTHWEST RESEARCH INSTITUTE

9503 W. COMMERCE - SAN ANTONIO, TX 78227-1301
(210) 684-5111

SHIPPING TICKET NO. 68669
(THIS IS NOT A P.O. NO.)
DATE: 07/06/10

PRIOR TO REPAIR OF ANY ITEM MENTIONED BELOW, PLEASE CONTACT 210/522-3074 WITH ESTIMATE AND FOR P.O. NO.

SHIP TO:
Columbia Analytical Services, Inc.
3725 E. Atlanta Ave.
Phoenix, AZ 85040
Tel: 602-437-0330
POC: Beth Proffitt
ATTN: Sample Receiving
VENDOR PHONE NO.
R.M.A. NO.

Please check box for method of shipment to and from Vendor
Circle specific method of shipment by Air Freight or UPS

SHIP VIA	TO VENDOR	RETURN TO SWRI
MOTOR FREIGHT	☐	☐
AIR FREIGHT (PRIORITY AIR GENERAL CARGO)	☐	☐
UPS (1 day, 2days or 7-10 days)	☐	☐
FEDERAL EXPRESS (1 day, 2 days)	☒	☐
OTHER	☐	☐

PPD. ☒ COLL ☐	INSURE FOR $ 0.00	DECLARED VALUE $ 0.00	GOVT. PROJ. ☐	DEPT NO. 08	PURCHASE ORDER NO.

AIR BILL OR W/B NO.	ACCT. OR PROJECT NO.	SWRI REQ. NO.	RETURN INITIATED BY	EXT.
	14406.05.001		Hutzler/pgl	

QUANTITY	DESCRIPTION & SERIAL NO.	ORIGINAL P.O., S.O., R.O., C.O.D./REQ. NO./B/O
	EOT Date	
	FUEL, AVIATION	
/	2 X 20mL SAMPLES CODED CL10-00932, TALLOW JET	
	UN 1863 FLAMMABLE LIQUID	

S.W.R.I. BUYER		BUYER NOTIFIED ☐	Please indicate if items are HAZARDOUS MATERIAL	☒ YES ☐ NO
NO. OF PACKAGES 1	TYPE OF PACKAGE ☒ BOX ☐ CTN ☐ DRUM ☐ _____	WEIGHT	DIMENSIONS	

REASON FOR SHIPMENT AND/OR REMARKS

☐ REPAIR (INDICATE PROBLEM IN REMARKS AREA) ☐ WARRANTY ☐ CREDIT ☐ CREDIT LESS RESTOCKING CHG. ☐ EXCHANGE ☐ OTHER (EXPLAIN IN REMARKS AREA)

REMARKS

DATE SHIPPED	VENDOR RECEIPT BY:

THIS FORM TO BE USED FOR ANYTHING SHIPPED FROM S.W.R.I.

IMPORTANT

PACKING LIST (PINK COPY) SHOULD BE ATTACHED TO THE OUTSIDE OF THE CONTAINER. REMAINDER OF SHIPPING TICKET SHOULD BE RETURNED TO SHIPPING & RECEIVING. PT.5 (GOLDENROD COPY) WILL BE RETURNED TO YOU FOR DEPARTMENT RECORDS.

rec'd 7/8/10 @ 1025 Leslie May - Xenco/Phx 24.4°C

SHIPPING COPY

Approved for public release; distribution unlimited.

Container type : VOAS

XENCO Laboratories

Sample Receipt Checklist

Client Name: Southwest Research Institute — Date and Time Received: 7/8/10 1025

Work Order Number: 10070103 — Checked by: lm

Checklist completed by: Leslie May Date: 7/8/10 — Logged In by: lm Date: 7/8/10

Matrix: L:q. Courier Name: Client Xenco FedEx — Reviewed by: SJ Date: 7/10/10

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody signed when relinquished and received? (lm)	~~Yes ☑~~	~~No ☐~~	Not Present ☐
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Samples received same day of collection?	Yes ☐	No ☑	Temp: 24.4 Wet Ice Present ☐
Where was the temperature reading taken at?	Sample ☑	Temp Blank ☐	Other:
VOA Water – VOA vials have zero headspace?	Yes ☐	No ☐	N/A ☑
Water – Microbiological bottles have ≤ 2.5 cm headspace?	Yes ☐	No ☐	N/A ☑
Water – All sample pH's acceptable upon receipt?	Yes ☐	No ☐	N/A ☑ Checked by:

If **No**, list all samples and bottle types that are not acceptable in Additional Comments section. Also state any correction actions.

Sulfide Water – Bottles have zero headspace?	Yes ☐	No ☐	N/A ☑ (zero headspace ≤ than neck of bottle)
Dissolved Water Analytes – Field Filtered?	Yes ☐	No ☐	N/A ☑
Are samples received deemed acceptable?	Yes ☐	No ☑	If **No** then complete section below

PC Notified	Date:	Init:	PC Init:		
Client Notified	Date:	Init:	L/M ☐	Date:	L/M ☐ Date:
Contact Name:	Action to take:	Analyze ☐	Cancel ☐	Hold ☐	Other:
Changes/Comments made on original COC?		Yes ☐	N/A ☐	Init:	Date:
Changes made in LIMS?		Yes ☐	N/A ☐	Init:	Date:

Additional Comments: temp out, no tests required on COC

CS-002-SRChecklist RV5

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Appendix M

SAE J1488 Water Removal - JP-8 + 100

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Table M-1. SAE J1488 – POSF4751

Test Description	SAE J1488	**Test No**	5
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC
Test Fluid	POSF 4751	**Test Date**	7/27/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	27
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	83
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100543

Average Upstream Water Content, ppm	2783
Time Weighted Average Water Removal	100.0
Total Water from Test Housing, mL	1915
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	31.7

MSEP

Before	39

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	83	75	0	5.1	0
2	10	2800	61	0	5.3	0
3	30	3230	67	0	6.1	318
4	50	2750	72	0	6.1	297
5	70	2790	64	0	6.3	276
6	90	2950	73	0	6.1	349
7	110	2130	63	0	5.9	250
8	130	2870	81	0	6.2	210
9	150	2740	64	0	6.1	215

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Table M-2. SAE J1488 – POSF6833

Test Description	SAE J1488	**Test No**	8		**Average Upstream Water Content, ppm**	2499
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1			
Test Fluid	POSF 6833 w/P39	**Test Date**	7/29/2010		**Time Weighted Average Water Removal**	100.0
Vacuum/Pressure	Pressure	**Test Temperature, °C**	25			
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	104		**Total Water from Test Housing, mL**	1970
Water Injection Rate (mL/min)	19	**SwRI Filter ID**			**Water from Cleanup filters, mL**	0
		Work Order No	TN100543			
Fuel/Water Interfacial Tension(mN/m)						
Before	34					
MSEP						
Before	0					

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	104	49	0	8.8	0
2	10	2700	83	0	11.2	20
3	30	2420	68	0	12.5	273
4	50	2580	67	0	13.4	271
5	70	2390	65	0	15.2	273
6	90	2340	59	0	14.4	302
7	110	2420	68	0	14.9	265
8	130	2650	65	0	15.6	274
9	150	2490	58	0	16.7	292

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Table M-3. SAE J1488 – POSF6834

Test Description	SAE J1488	**Test No**	3
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC
Test Fluid	POSF 6834 w/P41	**Test Date**	7/26/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	26
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	71
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100543

Average Upstream Water Content, ppm	2531
Time Weighted Average Water Removal	100.0
Total Water from Test Housing, mL	1856
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	33

MSEP

Before	0

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	71	63	0	6.9	-
2	10	3020	45	0	8.2	5
3	30	2970	48	0	9.3	290
4	50	2540	53	0	9.7	265
5	70	2300	58	0	10.1	241
6	90	2630	53	0	10.3	294
7	110	2010	58	0	10.3	231
8	130	2800	56	0	10.6	272
9	150	1980	42	0	10.8	258

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Table M-4. SAE J1488 – POSF6835

Test Description	SAE J1488	**Test No**	2
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC
Test Fluid	POSF6835 w/P44	**Test Date**	7/25/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	26
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	67
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100543

Average Upstream Water Content, ppm	2238
Time Weighted Average Water	100.0
Total Water from Test Housing, mL	1819
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	32.1

MSEP

Before	0

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	67	57	0	6.8	0
2	10	2390	61	0	9.9	0
3	30	1870	34	0	12.5	229
4	50	2070	54	0	13.8	234
5	70	2090	45	0	14.7	244
6	90	2320	50	0	15.7	280
7	110	2650	50	0	16.6	273
8	130	1880	43	0	17	251
9	150	2630	64	0	18.1	308

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Table M-5. SAE J1488 – POSF6836

Test Description	SAE J1488	**Test No**	4
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC
Test Fluid	POSF 6836 w/P47	**Test Date**	7/26/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	26
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	122
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100543

Average Upstream Water Content, ppm	2401
Time Weighted Average Water Removal	100.0
Total Water from Test Housing, mL	1852
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	30.5

MSEP

Before	0

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	122	55	0	5.1	**0**
2	10	2470	49	0	5.9	0
3	30	2520	55	0	7.3	266
4	50	2620	75	0	8.6	275
5	70	1890	96	0	9.8	248
6	90	2610	95	0	10.6	257
7	110	2150	56	0	11.2	240
8	130	2610	61	0	12.3	295
9	150	2340	50	0	12.7	271

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Table M-6. SAE J1488 – POSF6837

Test Description	SAE J1488	**Test No**	6
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1, UTC
Test Fluid	POSF 6837 w/P50	**Test Date**	7/28/2010
Vacuum/Pressure	Pressure	**Test Temperature, °C**	27
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	126
Water Injection Rate (mL/min)	19	**SwRI Filter ID**	
		Work Order No	TN100543

Average Upstream Water Content, ppm	2280
Time Weighted Average Water	100.0
Total Water from Test Housing, mL	2238
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	35.8

MSEP

Before	93

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	126	61	0	6.1	0
2	10	3150	55	0	7.8	15
3	30	1900	60	0	8.7	264
4	50	1540	58	0	8.9	265
5	70	2570	62	0	9.2	305
6	90	2480	70	0	9.8	361
7	110	2150	48	0	10.2	291
8	130	2350	46	0	10.5	376
9	150	2100	61	0	11.1	361

Approved for public release; distribution unlimited.

Table M-7. SAE J1488 – POSF6838

Test Description	SAE J1488	**Test No**	7		**Average Upstream Water Content, ppm**	2428
Test Engineer	Kavitha Moorthy	**Filter ID, Sponsor**	M1A1			
Test Fluid	POSF 6838 w/P39, P41, P44, P47, P50)	**Test Date**	7/29/2010		**Time Weighted Average Water Removal Efficiency (%)**	100.0
Vacuum/Pressure	Pressure	**Test Temperature, °C**	25			
Test Fluid Flow Rate (lpm)	7.6	**Water Saturation**	234		**Total Water from Test Housing, mL**	1705
Water Injection Rate (mL/min)	19	**SwRI Filter ID**			**Water from Cleanup filters, mL**	0
		Work Order No	TN100543			
Fuel/Water Interfacial Tension(mN/m)						
Before	27.2					
MSEP						
Before	0					

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	234	72	0	6	0
2	10	3300	81	0	8.5	1
3	30	2700	73	0	10.1	262
4	50	2220	56	0	11	260
5	70	2600	76	0	11.9	273
6	90	1900	77	0	12.4	240
7	110	2220	65	0	12.6	222
8	130	2540	78	0	13.1	224
9	150	1940	67	0	13.5	223

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Table M-8. SAE J1488 – POSF6839

Test Description	SAE J1488	Test No	1
Test Engineer	Kavitha Moorthy	Filter ID, Sponsor	M1A1, UTC
Test Fluid	POSF 6839 w/P41, P47, P50	Test Date	7/24/2010
Vacuum/Pressure	Pressure	Test Temperature, °C	26
Test Fluid Flow Rate (lpm)	7.6	Water Saturation	93
Water Injection Rate (mL/min)	19	SwRI Filter ID	
		Work Order No	TN100543

Average Upstream Water Content, ppm	2578
Time Weighted Average Water Removal Efficiency (%)	100.0
Total Water from Test Housing, mL	1809
Water from Cleanup filters, mL	0

Fuel/Water Interfacial Tension(mN/m)

Before	29.6

MSEP

Before	0

Sample ID	Test Time (minutes)	Upstream Water Content (ppm)	Downstream Water Content (ppm)		Pressure Drop (kPa)	Water Drained from test filter (mL)
1	0	93	63	0	4.7	0
2	10	3190	49	0	7	18
3	30	2610	72	0	8.5	226
4	50	2810	51	0	9.4	248
5	70	2520	65	0	9.4	318
6	90	2450	70	0	9.6	232
7	110	2320	61	0	9.9	272
8	130	2400	52	0	10.3	241
9	150	2320	79	0	10.6	254

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Appendix N

Certificates of Analysis (CofA)

Approved for public release; distribution unlimited.

Certificate of Analysis

Syntroleum®

R-8
SYNTHETIC JET FUEL

Syntroleum R-8 is synthetic jet fuel meeting the general requirements of MIL-DTL-83133F. It is not suitable for use in aircraft and is provided for development purposes only. This fuel contains between 23 and 29 mg/L phenolic antioxidant to improve storage stability.

SYNTHETIC DISTILLATE JET FUEL

Lot ___1___ Date: __06/20/08__

PHYSICAL PROPERTIES	TEST METHOD	UNITS	SPECIFICATION VALUE	ACTUAL
Density	ASTM D-4052	kg/L	0.75-0.77	0.7645
API	ASTM D-4052	°	51.6-56.5	53.6
Flash Point, min	ASTM D-93	°C	38	48
Ash	ASTM D-482	wt %	Report	< 0.001
Kinematic Viscosity @ 40°C	ASTM D-445	cSt	Report	1.44
Freeze Point, max	ASTM D-6892	°C	-47	-48
Cetane Index	ASTM D-976		Report	68.2
Saybolt Color	ASTM D-156		Report	+30
Distillation, IBP,% recovered	ASTM D2887	°C	Report	105
10% recovered, max		°C	186	157
20% recovered		°C	Report	174
50% recovered		°C	Report	218
90% recovered		°C	Report	279
FBP, max		°C	330	308

Health and Safety: The product(s) described herein may require precautions in handling and use. If deemed necessary, Material Safety Data Sheets (MSDS) for Syntroleum products are included with this document. You may also obtain this information by writing to us at the address below. Always consult the Material Safety Data Sheet for products you consider using.

Contact: Syntroleum 5416 South Yale Ave, Ste 400 Tulsa, OK 74135	QA/QC Approval	Approval to Ship	Date 6/20/08

THIS PRODUCT IS EXPERIMENTAL AND SYNTROLEUM CORPORATION MAKES NO REPRESENTATION THAT IT WILL BECOME COMMERCIALLY AVAILABLE. THE DATA PROVIDED HEREIN ARE PRESENTED FOR INFORMATION PURPOSES ONLY AND CANNOT BE GUARANTEED TO BE IDENTICAL TO THE PRODUCTS PRODUCED AT ANY TIME. NO WARRANTY IS EXPRESSED OR IMPLIED REGARDING SUCH OTHER INFORMATION, THE DATA UPON WHICH THE SAME IS BASED, OR THE RESULTS TO BE OBTAINED FROM THE USE THEREOF; THAT ANY PRODUCT SHALL BE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE; OR THAT THE USE OF SUCH OTHER INFORMATION OR PRODUCT WILL NOT INFRINGE ANY PATENT.

Revision Date: 18 June 2008

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Figure N-1. Certificate of Analysis - R-8 Lot 1 (CL09-0324)

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AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No: 2009LA16732002 Protocol: FU-AVI-0019 Cust Sample No: 5674
Date Sampled: 02/27/2009 Date Received: 03/02/2009 Date Reported: 03/05/2009
JON: DARPA001

Sample Submitter:
AFRL/RZPF
1790 Loop Road N
Bldg 490
WPAFB, OH 45433

Reason for Submission: AFRL Research
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133F Grade:JP-8

Qty Submitted: 1 gal

Method	Test	Min	Max	Result
ASTM D 2622 - 08	Sulfur (ppm)			<3
ASTM D 156 - 02	Color, Saybolt	Report Only		+30
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)	Report Only		0.002
ASTM D 1319 - 08	Aromatics (% vol)	Report Only		0.0
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)	Report Only		0.000
ASTM D 86 - 08a	Distillation			
	Initial Boiling Point (°C)	Report Only		156
	10% Recovered (°C)	Report Only		166
	20% Recovered (°C)	Report Only		170
	50% Recovered (°C)	Report Only		185
	90% Recovered (°C)	Report Only		227
	End Point (°C)	Report Only		244
	Residue (% vol)	Report Only		1.1
	Loss (% vol)	Report Only		1.0
ASTM D 93 - 08	Flash Point (°C)	Report Only		44
ASTM D 4052 - 96	API Gravity @ 60°F	Report Only		56.1
ASTM D 5972 - 05e1	Freezing Point (°C)	Report Only		-63
ASTM D 445 - 06	Viscosity @ -20°C (mm²/s)	Report Only		3.6
ASTM D 3338 - 08	Net Heat of Combustion (MJ/kg)	Report Only		44.1
ASTM D 3343 - 05	Hydrogen Content (% mass)	Report Only		15.3
ASTM D 1322 - 08	Smoke Point (mm)	Report Only		>40.0
ASTM D 1840 - 07	Naphthalenes (% vol)	Report Only		0.0
ASTM D 130 - 04	Copper Strip Corrosion (2 h @ 100°C)	Report Only		1a
ASTM D 3241 - 08a	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)	Report Only		0
	Tube Deposit Rating, Visual	Report Only		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)	Report Only		<1
ASTM D 1094 - 07	Water Reaction Interface Rating	Report Only		1
ASTM D 3948 - 08	WSIM			
	WISM	Report Only		99
ASTM D 5006 - 03	FSII (% vol)	Report Only		0.00
ASTM D 2624 - 07	Conductivity (pS/m)	Report Only		0
ASTM D 5001 - 08	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.87
ASTM D 4809 - 06	Net Heat of Combustion (MJ/kg)	Report Only		44.3
ASTM D 1319 - 08	Olefins (% vol)	Report Only		0.0
MIL-DTL-83133F	Workmanship	Report Only		Pass

Dispositions:
For information purposes only.

Approved By **Date**
Miguel Acevedo, Chief 03/05/2009
\\SIGNED\\

Figure N-2. Certificate of Analysis – Boeing JAL Blend (CL09-0501)

Approved for public release; distribution unlimited.

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No: 2009LA16732003 Protocol: FU-AVI-0019 Cust Sample No: 5675
Date Sampled: 02/27/2009 Date Received: 03/02/2009 Date Reported: 03/05/2009
JON: DARPA001

Sample Submitter:
AFRL/RZPF
1790 Loop Road N
Bldg 490
WPAFB, OH 45433

Reason for Submission: AFRL Research
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133F Grade:JP-8

Qty Submitted: 1 gal

Method	Test	Min	Max	Result
ASTM D 2622 - 08	Sulfur (ppm)			8
ASTM D 156 - 02	Color, Saybolt	Report Only		+30
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)	Report Only		0.002
ASTM D 1319 - 08	Aromatics (% vol)	Report Only		0.0
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)	Report Only		0.000
ASTM D 86 - 08a	Distillation			
	Initial Boiling Point (°C)	Report Only		159
	10% Recovered (°C)	Report Only		168
	20% Recovered (°C)	Report Only		172
	50% Recovered (°C)	Report Only		186
	90% Recovered (°C)	Report Only		225
	End Point (°C)	Report Only		242
	Residue (% vol)	Report Only		1.3
	Loss (% vol)	Report Only		0.7
ASTM D 93 - 08	Flash Point (°C)	Report Only		47
ASTM D 4052 - 96	API Gravity @ 60°F	Report Only		57.5
ASTM D 5972 - 05e1	Freezing Point (°C)	Report Only		-68
ASTM D 445 - 06	Viscosity @ -20°C (mm²/s)	Report Only		3.6
ASTM D 3338 - 08	Net Heat of Combustion (MJ/kg)	Report Only		44.2
ASTM D 3343 - 05	Hydrogen Content (% mass)	Report Only		15.4
ASTM D 1322 - 08	Smoke Point (mm)	Report Only		>40.0
ASTM D 1840 - 07	Naphthalenes (% vol)	Report Only		0.0
ASTM D 130 - 04	Copper Strip Corrosion (2 h @ 100°C)	Report Only		1a
ASTM D 3241 - 08a	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)	Report Only		0
	Tube Deposit Rating, Visual	Report Only		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)	Report Only		<1
ASTM D 1094 - 07	Water Reaction Interface Rating	Report Only		1
ASTM D 3948 - 08	WSIM			
	WISM	Report Only		99
ASTM D 5006 - 03	FSII (% vol)	Report Only		0.00
ASTM D 2624 - 07	Conductivity (pS/m)	Report Only		0
ASTM D 5001 - 08	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		1.03
ASTM D 4809 - 06	Net Heat of Combustion (MJ/kg)	Report Only		44.3
ASTM D 1319 - 08	Olefins (% vol)	Report Only		0.0
MIL-DTL-83133F	Workmanship	Report Only		Pass

Dispositions:
For information purposes only.

Approved By **Date**
Miguel Acevedo, Chief 03/05/2009
\\SIGNED\\

Figure N-3. Certificate of Analysis – Boeing CAL Blend (CL09-0502)

Approved for public release; distribution unlimited.

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No: 2009LA16732001 Protocol: FU-AVI-0019 Cust Sample No: 5673
Date Sampled: 02/27/2009 Date Received: 03/02/2009 Date Reported: 03/05/2009
JON: DARPA001

Sample Submitter:
AFRL/RZPF
1790 Loop Road N
Bldg 490
WPAFB, OH 45433

Reason for Submission: AFRL Research
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133F Grade:JP-8

Qty Submitted: 1 gal

Method	Test	Min	Max	Result
ASTM D 2622 - 08	Sulfur (ppm)			3
ASTM D 156 - 02	Color, Saybolt	Report Only		+30
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)	Report Only		0.002
ASTM D 1319 - 08	Aromatics (% vol)	Report Only		0.0
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)	Report Only		0.000
ASTM D 86 - 08a	Distillation			
	Initial Boiling Point (°C)	Report Only		161
	10% Recovered (°C)	Report Only		170
	20% Recovered (°C)	Report Only		174
	50% Recovered (°C)	Report Only		187
	90% Recovered (°C)	Report Only		226
	End Point (°C)	Report Only		247
	Residue (% vol)	Report Only		1.3
	Loss (% vol)	Report Only		0.5
ASTM D 93 - 08	Flash Point (°C)	Report Only		48
ASTM D 4052 - 96	API Gravity @ 60°F	Report Only		57.1
ASTM D 5972 - 05e1	Freezing Point (°C)	Report Only		-57
ASTM D 445 - 06	Viscosity @ -20°C (mm^2/s)	Report Only		3.6
ASTM D 3338 - 08	Net Heat of Combustion (MJ/kg)	Report Only		44.2
ASTM D 3343 - 05	Hydrogen Content (% mass)	Report Only		15.4
ASTM D 1322 - 08	Smoke Point (mm)	Report Only		>40.0
ASTM D 1840 - 07	Naphthalenes (% vol)	Report Only		0.0
ASTM D 130 - 04	Copper Strip Corrosion (2 h @ 100°C)	Report Only		1a
ASTM D 3241 - 08a	Thermal Stability @ 260°C			
	Change in Pressure (mmHg)	Report Only		0
	Tube Deposit Rating, Visual	Report Only		1
ASTM D 381 - 04	Existent Gum (mg/100 mL)	Report Only		<1
ASTM D 1094 - 07	Water Reaction Interface Rating	Report Only		1
ASTM D 3948 - 08	WSIM			
	WISM	Report Only		99
ASTM D 5006 - 03	FSII (% vol)	Report Only		0.00
ASTM D 2624 - 07	Conductivity (pS/m)	Report Only		0
ASTM D 5001 - 08	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.97
ASTM D 4809 - 06	Net Heat of Combustion (MJ/kg)	Report Only		44.2
ASTM D 1319 - 08	Olefins (% vol)	Report Only		0.0
MIL-DTL-83133F	Workmanship	Report Only		Pass

Dispositions:
For information purposes only.

Approved By	Date
Miguel Acevedo, Chief	03/05/2009
\\SIGNED\\	

Figure N-4. Certificate of Analysis – Boeing ANZ Blend (CL09-0503)

Approved for public release; distribution unlimited.

Alcor
PETROLAB, L.L.P.

20 Laboratory Road, Floresville, Texas 78114 Telephone 830-216-3113 www.alcorpetrolab.com

NuStar
San Antonio Products Terminal
P. O. Box 241017
San Antonio, Texas 78224-1017

February 22, 2010

Sample Type: Jet A
Tank Number.: 103
nt @ 1600 02/21/10 pu @ 0600 02/22/10

Sample Date: 02/22/10
Sample Time: 630

Volatility	Method	Specification		Result
Initial Boiling Point (°F)	D 86			320.0
Distillation 10% Rec (°F)		400	max	334.4
Distillation 50% Rec (°F)		Report		365.9
Distillation 90% Rec (°F)		Report		415.4
Distillation 95% Rec (°F)		Report		433.4
Distillation Final BP (°F)		572	max	459.5
Distillation Recovery (vol %)				98.9
Distillation Residue (vol %)		1.5	max	0.9
Distillation Loss (vol %)		1.5	max	0.2
Flash Point, Tag Closed (°F)	D 56	100	min	121.0
API Gravity @ 60 (°F)	D 1298	37.0 / 51.0		45.8
Cetane Index	D 4737	40.0	min	41.3
Particulate Matter Mgs/Gal	D 2276	3.0	max	0.8
Sulfur Wt %	D 7220	0.30	max	0.0001
Copper Strip	D130	No. 1	max	1A
Existent Gum Mgs / 100 Mls.	D381	7	max	<1.0
Fluidity				
Freezing Point (°F)	D 2386	-41.0	max	-76.9
Contaminants				
Color (Saybolt)	D 156	+15	min	+30
Appearance	D4176	clear/bright	pass/fail	Pass
Water Reaction: Change	D 1094	2.0	max	0
Water Reaction: Interface Rating	D 1094	2	max	1
Water Reaction: Separation Rating	D 1094	2	max	1
MSEP	D 3948	85	min	99

This Product Conforms to ASTM D1655 for the Above Tests: XX YES ____ NO

Reviewed and submitted by,

Chris Taylor CEO

Report Number: P022210A

Figure N-5. Certificate of Analysis – Valero Jet A (CL10-0429)

Approved for public release; distribution unlimited.

AFPET LABORATORY REPORT
HQ AFPET/PTPLA
2430 C Street
Building 70, Area B
Wright-Patterson AFB, OH 45433-7632

Lab Report No: 2009LA22106001 Protocol: FU-AVI-0124 Cust Sample No: POSF 6152
Date Sampled: 12/09/2009 Date Received: 12/10/2009 Date Reported: 12/18/2009

Sample Submitter:
AFRL/RZPF
1790 Loop Road N
Bldg 490
WPAFB, OH 45433

Reason for Submission: HRJ Testing
Product: Aviation Turbine Fuel, Kerosene
Specification: MIL-DTL-83133F Grade:HRJ

Qty Submitted: 2 gal

Method	Test	Min	Max	Result	Fail
MIL-DTL-83133F	Workmanship			Pass	
ASTM D 3242 - 08	Total Acid Number (mg KOH/g)		0.015	0.002	
ASTM D 1319 - 08	Aromatics (% vol)		1	0	
ASTM D 1319 - 08	Olefins (% vol)	Report Only		0.0	
ASTM D 2622 - 08	Sulfur (% mass)		0.0015	0.0018	X
ASTM D 3227 - 04a	Mercaptan Sulfur (% mass)		0.002	0.000	
ASTM D 86 - 09	Distillation				
	Initial Boiling Point (°C)	Report Only		151	
	10% Recovered (°C)	157	205	161	
	20% Recovered (°C)	Report Only		166	
	50% Recovered (°C)	168	229	182	
	90% Recovered (°C)	183	262	237	
	End Point (°C)		300	259	
	T50 - T10 (°C)	Report Only		21	
	T90 - T10 (°C)	Report Only		76	
	Residue (% vol)		1.5	1.1	
	Loss (% vol)		1.5	0.9	
ASTM D 93 - 08	Flash Point (°C)	38	68	43	
ASTM D 4052 - 09	Density @ 15°C (kg/L)	0.751	0.840	0.751	
ASTM D 4052 - 09	API Gravity @ 60°F	37.0	57.0	56.8	
ASTM D 5972 - 05e1	Freezing Point (°C)		-47	<-77	
ASTM D 445 - 09	Viscosity @ -20°C (mm²/s)		8.0	3.3	
ASTM D 445 - 09	Viscosity @ -40°C (mm²/s)	Report Only		6.4	
ASTM D 445 - 09	Viscosity @ 40°C (mm²/s)	Report Only		1.1	
ASTM D 4809 - 09a	Net Heat of Combustion (MJ/kg)	42.8		44.3	
ASTM D 3338 - 08	Net Heat of Combustion (MJ/kg)	42.8		44.1	
ASTM D 3343 - 05	Hydrogen Content (% mass)	13.4		15.4	
ASTM D 1322 - 08	Smoke Point (mm)	25.0		50.0	
ASTM D 1840 - 07	Naphthalenes (% vol)		0.1	0.0	
ASTM D 130 - 04	Copper Strip Corrosion (2 h @ 100°C)	1 (Max)		1a	
ASTM D 7224 - 08	WSIM	Report Only		95	
ASTM D 3241 - 09	Thermal Stability @ 260°C				
	Change in Pressure (mmHg)		25	0	
	Tube Deposit Rating, Visual	<3 (Max)		1	
ASTM D 381 - 04	Existent Gum (mg/100 mL)		7.0	<1.0	
ASTM D 5452 - 08	Particulate Matter (mg/L)		1.0	0.4	
MIL-DTL-83133F	Filtration Time (min)		15	4	
ASTM D 1094 - 07	Water Reaction Interface Rating	1b (Max)		1	
ASTM D 5006 - 03	FSII (% vol)	Report Only		0.00	
ASTM D 2624 - 07	Conductivity (pS/m)	150	450	400	
ASTM D 5001 - 08	Lubricity Test (BOCLE) Wear Scar (mm)	Report Only		0.76	
ASTM D 976 - 06	Cetane Index, Calculated	Report Only		58	

Dispositions:
For information purposes only.

Figure N-6. Certificate of Analysis – Camelina HRJ SPK (CL10-0278)

Approved for public release; distribution unlimited.